"SELECTION OF APPROPRIATE FOREST TREE SPECIES FOR AFFORESTATION AND REFORESTATION PROGRAMME OF BUNDELKHAND REGION"

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BY

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DECLARATION

I hereby declare that the thesis entitled "**Selection of appropriate forest tree species for Afforestation and Reforestation programme of Bundelkhand Region**"with the exception of the guidance and suggestions received from my supervisor Dr. J.P. Tripathi M.Sc., Ph.D., F.A.P.S. - F.R.M.S., Head, department of Botany and Silvipasture, Bipin Bihari (P.G.) College, Jhansi is submitted for the award of the degree of Doctor of Philosophy in Botany, Faculty of Science, Bundelkhand University, Jhansi.

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ACRONYMS /ABBREVIATIONS

ha	Hectare
FSI	Forestry survey India
S.No.	Seriol Number
mm	Millimeter
hoc anno	In this year
^0C	Degree Celsius
Vern.	Vernacular Name
in.	Inch
lb	Pound
ft	Feet
cm	Centimeter
gm	Gram
pH	Potentiality of hydrogen ions
RH	Relative Humidity
^0F	Degree Fahrenheit
Kg	Kilogram
%	Percentage
TP	Top of the germination paper
GA_3	Gibberelic acid
IAA	Indole Actic Acid
IBA	Indole Butryic Acid
ppm	Part Per Million
TTC	Tetrazolium Trichloride
St	Sawdust
Sd	Sand
Sl	Soil
C	Control
SE	Standard Error
A.V.	Average Value
i.e.	That is
et.al.	With other people
A.L.	*Albizia lebbeck*
A.P.	*Albizzia procera*
A.I.	*Azadirachta indica*
B.M.	*Butea monosperma*
D.S.	*Dalbergia sissoo*
L.L.	*Leucaena leucocephala*
T.A.	*Tamarindus indica*
Max .	Maximum
Min.	Minimum

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INTRODUCTION

Forests undoubtedly make up an important constituent of the earth's environment. They add beauty to the landscape. They make the climate salubrious. They act as environment buffers. They consume large quantities of water through the roots of plants and lose it through transpiration by the leaves. Extensive forests help in increase of precipitation. They intercept heavy rainfall and release the water steadily and slowly to the soil underneath to prevent the soil particles from being washed away with the water. The roots of the innumerable small plants and trees hold the soil particles in place (Kumar, 2001).

Forest are the major natural resources to fulfil the requirements of men on this planet like fuel, food, clothings, stationary, medicines, fodder for livestock animals and other industrial products. In addition to these daily needs of human beings, they also conserve the global environment by binding soil, consuming CO_2 and by releasing oxygen. Thus, also maintain the balance of these important gases in nature. About half of the world's forests are located within tropics in three main regions namely tropical America, tropical America and Asia-Pacific region. In broad terms, the total estimated area of tropical forest is over 2000 million hectares can be regarded as tropical rain forest. It is commonly believed that tropical forest plays an important role in global ecology and is of vital importance in maintaining environment quality for beyond the conifers of the tropics (MAB, 1972). In our country about 74.9 million hectares of the land is covered by different forests, of which most of the area is supported by dry and moist deciduous forests (FSI, 1999).

Many fold increase in human population has led to tremendous demand for energy, food and shelter. These demands of today's society mainly for their luxurious and materialistic life, have posed a potential threat for the existence of different type of forests, by harvesting forests fuel and others daily needs, clearing forests land for cultivation of agricultural crops, construction big dams for irrigation and generation of hydroelectric power, and by replacing forests by cemented house for shelters, while these activities of humans have resulted in disappearance of large tracts of forests disturbing the climate and its behavior. It has also caused heavy erosion of soil resulting into recurrence of devastation floods and loss of the top soil. This heavy intrusion of humans

into forests has appreciably disturbed the ecological grazing food chain and cause extinction of wild life from many parts of the globe. United Nations framework convention on climate change defines climate change as, "A change in climate which is attributed directly or indirectly to human activity that alter the composition of global atmosphere and which is in additions to natural climate variability observed over comparable time periods." Climate change on the earth planet is inevitable. It was only because of this change that the earth becomes suitable for human beings, after the snow receded to Polar Regions from the equator.

In the natural system, the earth's atmosphere has been accumulating heat in a slow and continuous way by the optical properties of the CO_2 gas. But in the recent past, this rate of change has been triggered due to tremendous illicit activities of civilized vast population of human being. Observed changes in temperature, precipitations, snow cover, sea level and extreme weather conditions confirm that global warming is a reality which is an ultimate outcome of manmade pollution. Scientific models and observations for the past 1000 years provide evidence that global warming is due to anthropogenic increase in green house gases (Pandey, 2000).

These alarming trends of development with destruction have lately attracted the concern of scientists, administrators, politicians and layman alike, which resulted into new generation of conservators and ecologists who are concentrating their efforts to check further damage to these ecosystems and to restore the faded forest areas at national and international levels. Some of the international organizations like International Union for Nature and Natural resources (IUCN) and UNESCO through man and biosphere programme are doing their utmost by persuading national government to initiate various laws and punitive measures to check deforestation and to initiate the researches for the restoration of forests.

The success of afforestation and reforestation programmes depends appreciably, upon the understanding of the species composition, interaction among different species and their environment, because the better understanding of structure and function of forest ecosystem in questions may lead to the identification of fast-growing species and the species with commendable capacity to bind the soil (Halanda and Ting, 1993; Hooda et.al. 1993; Maikuri, 1993; Pathak 1988). The second step for these programmes involves the study of behaviour of seed and its germination and the means for fast germination of seeds. The third step which is very crucial deals with the study of seedling growth and the

media and other environmental factors which can facilitate its faster growth with subsequent maintenance of seedlings in the nursery. The ecologist made good progress by long term, well planned and exhaustive field studies towards the understanding of their forests. Their efforts have been quite successful in generating vast stretches of artificial forests and regeneration of natural forests in a vast area, although substantial studies have been performed on the dynamics and structure of tropical rain forests and deciduous forests (Chen et al., 1997; Radoglous and Teskey, 1997; Thakur et al. 2000).

A substantial amount of work has been carried out and is still continuing on tropical forests especially dry deciduous forests of central India (Karemulla (2002), Banerjee (1995), Mani (1999), Nandeshwar and Vijaya Raghban (2006), Devendra Kumar (2007), Gill and Ajit (2004), Dubey and Rathore (2004), Sood and Tyagi (2006), In Temperate forests such contributions are made by Konwar and Kataki (2001), Bhardwaj (2001), Nagarjun and Mertia (2006), Chopra and Hudda (2001). The workers like Rawat and Tyagi (2000), Thakur and Mehta (2006), Pawar and Pankaj (2000), Tabassum and Bhatt (2000), Raina and Pardeep (2000), Dar and Farooq (2002) have studied the structure and function of these ecosystems.

A good deal of research works has been done out side the country by Stewart (1996) Sedjo and Roger (2001), Saw(1992), Schubert and Adams (1992) Shalhebet and Bernstain (1968), Andrasko (1990), Papadopal (2002), Kumar (2002), Brown (1996) and Agboola and Ebofin (2005).

These studies have mainly dealt with the structure and function of the forests and the relation of different species to their environment dynamics of species, biotic interferences on the structure and composition of these forests. The studies are few which pertain to the understanding of germination behaviour of seeds the factors which affects or favour to obtain the knowledge regarding the growth and dynamics of seedlings in its initial phase and other environmental variables which can help in their sustenance fast growth and maintenance in nurseries (Toky, et al. 1993 and Giri, et al. 2000).

Seed quality comprises both (1) the physiological viability and vigour of seeds and their genetic quality and (2) their ability to produce healthy offspring which are normally well suited to the sites where they are planted, but also have a positive influence on the goods or services which they are indented to provide. In other words, carefully selected good seeds will lead to the successful establishment of plantations (Ram Prasad, 1999).

Deforestation and forest degradation have many negative consequences Tropical forests have the richest biotic environments in terms of the number of plant and animal species. Their loss causes the extinction of increasing numbers of these species, and forest degradation leads to serious reduction in the genetic diversity of others. The loss of tropical forests has already affected millions of people through increased flooding, soil erosion and siltation of waterways, drought, shortages of fuel wood timber, and displacement of societies and cultures. The destruction of forests also produces adverse impact on the ecosystem and can cause irreversible changes, the most serious of which may be due to the large-scale exposure of natural soil systems, leading to increased erosion and, in turn, indirectly affecting water resource development (Kumar, 2001).

An immediate response to the growing problem of deforestation is to protect substantial areas of remaining tropical forests, to improve forest management, and to plant more trees. Worldwide, less than 5% of the remaining tropical forests are protected as parks or reserves. Some countries have already established successful reserves, and many have taken steps to improve forest management. Some have restricted the harvesting of timber; others have improved the harvesting technology.

The survey and demarcation of forests; the study of natural regeneration, biotic interferences and the silvicultural characteristics; the study of the germination and growth of tree species have become imperative. New skills are to be generated in the managerial and technical fields to upgrade the forests. The realization of the concept of social forestry has also added a new responsibility on the public sector. The welfare of the tribal and other classes of the people below the poverty line, as yet another equally important aspect of the forestry which righlty deserves a greater attention.

Many programmes have been launched and much attention is being paid on the afforestation and reforestation of these areas of low fertility. To achieve this goal of plantation, it is felt that there is an urgent need to select and develop some economically important forest tree species that may survive under arid and semi arid conditions of these regions.

In order to maintain better eco-climatic conditions the necessity of the present study on the structure and reproduction of local forest trees has become very significant, since it is more or less directly connected with the well being of the local people. There are several dominated trees luxuriantly growing on the dry eroded areas of Bundelkhand and are well adapted species to the hilly tracts with inhospitable shallow soils like

Azadiracta indica A. Juss, Albizzia lebbek (L.) Benth, *Albizzia procera* (Roxb.) Benth, *Butea monosperma* (Roxb.) Lam. Taubert, *Dalbergia sissoo* (Roxb), *Holoptelia integrifolia* Planch, *Leucaena leucocephala* (Lam.) De Wit. *Tamarindus indica* L. etc.

An attempt should be made by social organizations and forest department to develop these economically important forest tree species with the support of common people so that we can minimize natural calamities to certain extent.

The Present study was conceived to fill this gap in the knowledge of seed germination and seedling growth dynamics of some local tree species to some extent by studying the following aspects:

- Morphological study of seeds (Seed size and weight) to establish their correlation with germination percentage.
- Collection of seeds by various prescribed scientific method and to study a correlation of germination percentage with method of collection.
- Impact assessment of various environmental conditions on the seed germination and seedling growth behavior.
- Effect of potting media, light, irrigation and phytoharmone on growth and behavior of different component of the seedling
- Analysis of growth dynamics of the seedlings during their initial growth phase.

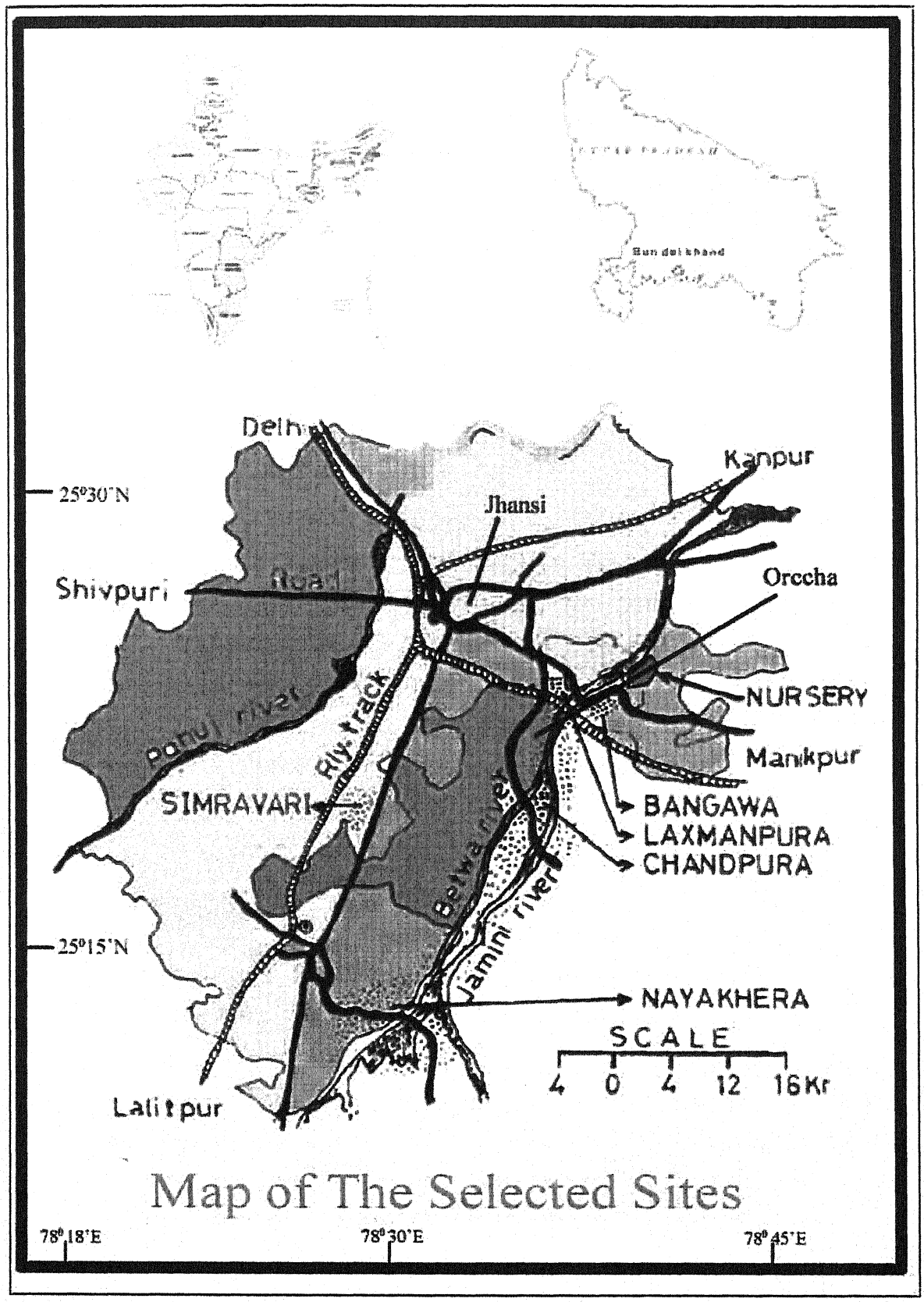
STUDY AREA AND CLIMATE

Bundelkhand lies at $23^0 8'$:$26^0 30'$ N latitude and 78^0 11':81^0 3' E longitudes in between the Indo-Gangetic Plain to the north and the Vindhya Range to the south. It is a gently-sloping upland, distinguished by barren hilly terrain with sparse vegetation, although it was historically forested. The plain of Bundelkhand are intersected by three mountain ranges, the Vindhya, Fauna and Bander chains, the highest elevation not exceeding 600 meters above sea-level. Beyond these the country is further diversified by isolated hills rising abruptly from a common level, and presenting from their steep and nearly inaccessible scraps eligible sites for forts and strongholds of local kings. In general; slope of the country is towards the north-east, as indicated by the course of the rivers which traverse or bound the territory, and finally discharge themselves into the Yamuna river.

The principal rivers are the Sindh, Betwa, Tons, Dhasan and Chambal. The kali Sindh, rising in Malwa, marks the western frontier of Bundelkhand. Parallel to this river, but farther east, is the course of Betwa. Still farther to the east flows the Ken, followed in succession by the Bagahin and Tons. The Yamuna and the Ken are the only two navigable rivers. Not withstanding the large number of streams, the depression of their channels and height of their banks render them for the most part unsuitable for the purpose of irrigation, which is conducted by means of ponds and tanks. These artificial lakes are usually formed by throwing embankments across the lower extremities of valleys, and thus arresting and impounding the waters flowing through them.

The major towns are Jhansi, Datia, Lalitpur, Sagar, Damoh, Jalaun, Panna, Hamirpur, Banda, and Chhattarpur. However the city of Gwalior is under a wide influence of Bundelkhand. Bundelkhand's most well known place, however, is khajuraho which has a number of 10th century temples devoted to fine living and eroticism. The mines of Panna have been famous for magnificent diamonds; and a very large one dug from the past was kept in the fort of Kalinjar.

Bundelkhand is the most common Hindi dialect area. The region is predominantly Hindu. Jainism is historically significant, and several Jain Tirthas are located in this region. Many prominent Jain scholars of the 20th century have been from this region.
Bundelkhand region is spreaded over 71618 Km Sq. the forest area of Bundelkhand covers 12.10 lakh hectare of land which accounts for 17.28 percent of the total reporting



Map of The Selected Sites

area of the region. Out of this, the Madhya Pradesh part occupies 9.63 lakh hectare (79.6%) and Utter Pradesh part 2.47 lakh hectares (20.40%).

The Bundelkhand region was densely forested until the late 18th century. After the turn of the century, rising demands for wood and agricultural expansion led to increasing levels of deforestation. Post independence population growth and the emergence of the green revolution brought even larger tracts of land under the plough and further increased wood-based energy needs. These factors, combined with poor land management and ruthless government approved commercial logging, have drastically reduced forested area in the region. Today, only small patches of dry miscellaneous and thorn forests comprised of Dhak, teak, mahua chiraungi khardai, dhau and khair, trees remain. Vegetation primarily consists of scrub forest (siari, khatai, gunj, bel, ghout trees) and scrub brush, much of it open canopy with large tracts of land classified as "wastelands". Prevailing soil type are a mix of black and red; the letter being relatively recently formed, gravely and shallow in depth, and thus unable to retain moisture well. Much of the region suffers from acute ecological degradation due to topsoil erosion and deforestation, leading to low productivity of the land. Soil erosion is a persistent problem that is aggravated by the hilly landscape, high winds and the poor quality of the soils, leading to the widespread growth of gullies.

The region is part of Narmada Valley dry deciduous forests eco-region. The original vegetation consisted of tropical dry forest, dominated by teak (*Tectona grandis*) associated with ebony (*Diospyros melanoxylon*), *Anogeissus pendula, Anogeissus latifolia, Lagerstroemia parviflora, Terminalia tomentosa, Terminalia arjuna, Lannea coromendelica, Hardwickia binata and Boswellia serreta.* It was mostly forested until the late 18th century, when intensive logging of the forests accelerated. Deforestation accelerated after the consolidation of British control in the 19th century.

The forest vegetation of Jhansi and its adjoining area is transitional between the southern tropical dry deciduous type and the Northern tropical dry deciduous type. Forest in Jhansi region cover only 6.48 percent of its total geographical area and the per capita forest area is only 0.037.

2.1- Study Sites:

For seed collection, various sites were selected after preliminary survey of the whole region. Details of these sites are illustrated below:

Site A: The forest of Bangawa, District Jhansi (U.P) is situated on the eastern side of Jhansi-Mauranipur road and is nearly 13 km from Jhansi. About 180.70 ha areas of the forest is reserved and in general the forest is tropical mixed dry deciduous type.

Site B: Chandpura forest of Tikamgarh (M.P.) range.This forest is situated on Jhansi-Tikamgarh road near Orchha (M.P.)

Site C: Laxmanpura forest of Tikamgarh range (M.P.).This forest is situated on either sides of the Orchha-Baruasagar rail tract, running from Orchha railway station to the railway bridge river–Betwa. It is about 13 km from Jhansi by road. The natural growth of trees in this forest has been mostly destroyed.

Site D: Naya khera forest of Talbahet (Lalitpur) range, U.P. is situated near Sukwan-Dukwan water reservoir and is nearly 40 km away from Jhansi via Babina Cantt.

2.2 Nursery:

For germination, seedling growth and silvicultural studies, the author made use of the Bangawa forest nursery with due permission of the forest department Jhansi. The nursery is situated on the eastern bank of river Betwa and is about 15 km from Jhansi on Jhansi-Mauranipur road.

2.3 Soil:

Soil is by far the most important single factor controlling the distribution, composition, production and quality of any forest tree species. The soil of the region in general are poor in nitrogen, low and medium in phosphate and medium to high in potassium content. Many times different soils occur on a small area giving a typical mosaic appearance. These soil are broadly grouped in Red and Black soils and is further classified into Rakar, Parwa, Kabar and Mar soil series on the basis of their texture and colour.

The soil of the area reflects the following patterns::

(i): Red soil in hilly region shows an eroded appearance.

(ii): Brown soil comprises $CaCO_3$ and gravel layers found on level plains and uplands near catchment areas.

(iii): Black and plain soil with high percentage of clay on low lying areas under restricted drainage.

Bundelkhand soils ae residual in nature and are formed *in situ* from the parent material in general. Red soils are originated from the parent rocks like gneiss and granite. Sometimes they are also formed from the sandstones. Black soils in contrast are formed partly *in situ* and partly transported. The parent material of black soils is lime stone and trap. Rock minerals of the parent material of Bundelkhand soils are comprised of Quartz, Feldspar, Hornblende, Chlorite and Mica. Dominant soil forming factors besides parent material are topography and climate.

2.4 Topography and Geology :

Bundelkhand is an old landmass composed of horizontal rock beds resting on a stable foundation. The landscape is rugged, featuring undulating terrain with low rocky outcrops, narrow valleys, and plains. Surface rocks are predominantly granite of the Lower Pre Cambrian/Achaean period. Some Dharwarian and Vindhayan rocks present in the region contain minerals of economic value. Sandstone, shales and limestone of high quality, along with Dyhes, Sills and the famous pink Achaean gneiss rocks, are also found in places.

This region is covered with Vindhyan ranges running east to west and presenting undulating plains which are relieved at places by rocky hills or ravine-edged river beds. The tract presents an undulating terrain with rocky outcrops with considerable variations in the types of soil, its colour, texture and depth etc.

The topography of the region lies within 300 m above mean sea level in general and exceeds over 450 m in some cases. The hypsometric curve of the region shows that above 67.7 percent of the area is under 300 m and 28.7 percent lies between 300 and 400 m with small area (3.6%) above 450 m. Betwa, Pahuj and Jamini are the main tributaries of the river Yamuna, flowing through the tract. The banks of these rivers are flanked by most of the forests of this region

2.5 Climate –

The Bundelkhand Region is marked by extremes of temperature, reaching the mid to upper 40^0 C during the summer months and dropping as low as 1^0 C in winter. During the summer season, high temperatures in the plain cause low pressure areas that induce movement of the monsoon. The temperature begins to rise in February and peaks in May-June. Hot breezes known locally as *loo* are common during this period. Centrality of the

region imposes on it the features of a transitional climate between the maritime of the East coast (Bay of Bengal) and the tropical continental dry type of the west (Rajasthan). The tract is characterized by a long and intensely hot summer, low and irregular rainfall and short chilly winter.

2.6 Rainfall:

The rainfall distribution pattern is irregular, with approximately 90% of all rainfall in the region caused by the monsoon, falling from June to October. Average rainfall per year is 800-900 mm, but most is lost to runoff. July and August are the months of maximum rainfall, while November and April are the driest months of the year. The scant winter rainfall is useful for the cultivation of 'rabi' crops, but it is usually inadequate without access to supplementary irrigation source. Rainy season commences from late June and continues up to early October. A greater part of annual rainfall is received during this season. This is characterized by heavy rains, high temperature and relative humidity. Rainy season is succeeded by winter which lasts till February.

About 90 percent of the total precipitation is received between mid of the June and the end of the September. There were occasional showers during winter months, the distribution of rainfall was often erratic and even the wet months i.e., July and August experienced long dry spells. Some estimation about rainfall conditions have been given by Rizvi, Singh, Ramesh, Yadav, Tewari, Dadhwal, K.R. (2001) again by Singh, Ramesh, Rizvi, Solanki (2002).

2.7 Temperature –

Mean annual temperature of the region is 26.5° C. May and June are the hottest months and record maximum temperature of 43° C to 47° C, whereas the minimum temperature reaches 4° C to 5° C during December and January reported of occasional freezing temperature.

The summer usually begins by the middle of March, extends up to the end of June and ends with the onset of monsoon. The severity of the heat during day time is aggravated by strong hot and generally dustless westerly winds which blow throughout May and June and is characterized by comparatively clear and dustless sky.

On the basis of moisture index, Jhansi has been considered semi arid eco-climatically with moisture index ranging from 40-60, in all; the region is subjected to steep slope, quick run off, erratic and scanty rainfall, periodic dry spells and unfavorable geology.

TABLE 1 DISTRIBUTION, FLOURISTIC AND OTHER CHARACTERISTICS OF THE FOREST-TYPES PRESENT IN JHANSI

Sr. No.	Types of Forest	Sub Type	Location and Characteristics	Floristic
	I RESERVE FORESTS			
1.	Tropical riparian forests	4E/R.s.-1	These are post-climax Forests occurring along The river banks of Betwa.	*Bauhina vahlii, Butea superba, Carissa spinarum, Eugenia heyniana, Flacourtia indica, Gardinia turgida, Helicteres isora, Mallotus Phillipinensis, Manilkara hexendra, Mitragyna parviflora, Terminalia arjuna, Vantilago calyculata, Vitex negundo, Woodfordia frutioose.* etc.
2.	Dry teak forests	5AC-1(b)	Isolated patches near the banks of river Betwa.	*Anogeissus latifolia, Carissa carandas, Diospyros tomentosa, Ichnocarpus frutescens, Lgerstroemia parviflora, Lannea coromandelica, Mucuna pruriens Sterculia urens, Tectona grandis, Terminalia arjuna, Zizyphus nummularia* and *Zizyphus oenoplia* etc.
3.	Southern-Northern dry Mixed deciduous forests	5A/C-2 & 5B/C-2	This type occurs on the plains north of Vindhyan highlands in Talbehat and Jhansi Ranges	*Balanites aegyptiaca, Bridelia retusa, Carissa carandes, Combretum decandrum, Cryptolepis buchanani, Helicteres isora, Holoptelia*

				integrifolia, Ichnocarpus frutescens, Lannea coromandelica, Nyctanthes arbortristis, Pterocarpus marsupium, Securinega virosa, Zizyphus mauritiana, Zizyphus nummularia etc.
	II GENERAL EDAPHIC TYPE			
4.	*Anogeissus pendula* forests	5E-1	This type occurs on Quartz ridges, hillocks And plains in Bangawa, Ghaisauli, Mankua, Simravari blocks of Jhansi ranges with Almost pure patches of 'Kardhai'	*Abrus precatorius, Acacia catechu, Anogeissus pendula, Bauhinia racemosa, Butea monosperma, Carissa carandas, Lannea coromandelica, Myrsine africana, Nyctanthes arbortristis, Ventilago calyculata, Vitex negundo, Zizyphus mauritiana, Zizyphus numularia and Zizypus oenoplia etc.*
5.	*Anogeissus pendula* Scrub forests	5E-1/DS-1	This type occurs where the conditions are Extremely adverse due To biotic influences. *A. Pendula* is reduced To shrub. Common in Athothena, Palinda & Rasoi of Jhani ranges.	*Acacia catechu, Barleria strigosa, Bauhinia racemosa, Butea monosperma, Carissa spina rum, Ipomoea pestigridis, Lantana camara, Rhus mysorensis, Trichosanthes cucumerina, Zizyphus nummularia and Zizyphus xylopyrus* etc.
6.	*Boswellia* forests	5E-2	Saiyyar and Sijwaha Blocks of Jhansi range and in the ravines flanking the river Pahuj.	*Acacia catechu, Acacia leucophloea, Boswellia serrata, Lageratroemia parviflora, Lannea coromandelica, and Sterculia urens etc.*
7.	*Butea* forests.	5E:5	on badly drain clay soil in valleys hillocks and along the river banks in	*Acacia catechu, Butea monosperma, Carissa carandas, Lagerstromia*

			Bamarughurra, Bijapur and Seikkar blocks of Jhansi range With open canopy	*parviflora, Wrightia tinctoria and Zizyphus nummularia* etc.
8.	Ravine thorn forests	6B/C-2	Confined to ravenous area In patgches along the river Betwa. Canopy is always open and is characterized by arid conditions	*Acacia catechu, Acacia nilotica, Capparis deciduas, Cappris zeylanica, Carissa carandas, Dichrostachyas cinerea, Flacourtia indica, Prosopis spicigera and Zizyphus numularia* etc.

TABLE 2.1: METEOROLOGICAL DATA RECORDED IN THE YEAR 2004

Months	Temperature (^{0}C)		RH% Period		Rainfall (mm)	Rainy Days (No)	Wind Velocity (Km/hr)	Bright Sunshine (hrs/day)	Evaporation (mm/day)
	Max	Min	Ist	2nd					
January	24.1	6.2	90.8	39.6	00.0	-	3.26	8.96	2.84
February	31.6	11.7	87.3	38.5	00.0	-	3.38	9.7	4.2
March	31.8	14.1	84.5	43.0	24.2	2	4.85	9.1	5.1
April	32.8	19.8	62.4	25.2	0.8	-	5.62	9.0	8.9
May	41.8	25.6	61.8	34.8	52.2	4	7.53	7.7	10.5
June	39.1	26.8	68.0	38.5	53.7	4	8.3	7.9	10.1
July	32.9	25.8	87.0	53.2	138.6	9	8.8	3.7	6.48
August	32.0	24.4	89.5	67.5	93.3	8	7.6	4.5	5.7
September	34.8	22.9	86.5	50.5	7.6	2	4.2	8.9	5.6
October	34.8	17.9	77.8	35.4	00	-	3.4	9.2	5.1
November	29.9	11.9	85.3	33.5	00	-	2.4	8.7	3.3
December	25.6	8.5	84.0	39.3	4.8	1	2.5	8.1	2.6

TABLE 2.2: METEOROLOGICAL DATA RECORDED IN THE YEAR 2005.

Months	Temperature (^{0}C)		RH% Period		Rainfall (mm)	Rainy Days (No)	Wind Velocity (Km/hr)	Bright Sunshine (hrs/day)	Evaporation (mm/day)
	Max	Min	Ist	2nd					
January	21.6	6.24	70.6	45.4	2.4	-	3.5	6.6	2.4
February	27.5	9.9	86	36.8	2.8	1	4.0	8.8	3.9
March	33.1	15.1	76.5	31.3	37.2	2	5.	9.1	5.3
April	38.3	17.6	58.2	25.6	8.2	1	6.3	9.4	8.6
May	43.1	24	47.3	28.5	00	-	6.3	9.8	11.9
June	41.7	29.9	60	35.3	14.2	2	8.5	6.0	11.95
July	32.6	25.2	90.6	68.2	214.6	14	7.5	4.5	5.4
August	33.7	24.3	86.8	68	81.8	4	6.7	6.8	5.4
September	33.3	23.9	90.8	64.5	75.5	7	5.7	7.1	4.4
October	34.1	15.5	82.2	30	1.8	-	4.1	9.7	5.4
November	30.1	10.1	82.3	24.5	00	-	3.4	8.9	3.5
December	24	5.2	90.3	37.3	1.2	-	2.7	8.6	2.3

TABLE 2.3: METEOROLOGICAL DATA RECORDED IN THE YEAR 2006

Months	Temperature (^{0}C)		RH% Period		Rainfall (mm)	Rainy Days (No)	Wind Velocity (Km/hr)	Bright Sunshine (hrs/day)	Evaporation (mm/day)
	Max	Min	Ist	2nd					
January	24.2	6.2	87	42	1.8	-	2.5	8.7	2.8
February	26.4	10.3	88.3	31.8	39.2	4	4.0	8.1	3.2
March	32.5	13.2	79	27.8	00	-	4.4	10.1	5.7
April	40.3	20.7	55.4	23.4	2.0	-	5.9	10.1	9.8
May	41.8	25.6	52.8	27	13.3	2	7.7	9.6	11.5
June	39.1	27.3	67.3	44.5	143.3	5	10.1	8.4	10.9
July	33.7	25.4	86.8	64.4	140.3	13	7.9	5.1	5.7
August	33.1	24.9	89.8	65.8	85.3	9	6.0	5.8	4.4
September	34.1	23.4	90	57.8	119.8	6	3.3	0.8	4.5
October	35.0	13.9	77.8	25.6	00	-	2.8	8.8	5.1
November	30.3	10.0	87.5	28.8	00	-	1.8	7	3.1
December	24	6.0	87.8	39.8	9.6	1	2.3	6.2	2.3

REVIEW OF LITERATURE

Researches on various aspects of seed biology were started during eighteenth century. It is only during the last hundred years that foresters could realize the understanding of physiological and genetical qualities of seeds in success of reforestation programme. Some notable contributions on various aspects of seed biology are available in the form of monographs and edited texts. Some of the important publications are by Baldwin (1942),Salisbury (1942) Croker and Barton (1953), Mayer and Mayber (1963), Hatano and Asakawa (1964), Kozlowski (1972) McDonough (1977), Sen (1977) Bewley and Black (1978), Tewari (1992), Rathore (2004), Pathak (1981) and Tewari (1994).

The biological, physiological and ecological aspects of seeds of temperate forest species have been worked out in detail in many parts of Europe and North America. Some of the important contributions on ecological and eco-physiological aspects of seed and its germination are by Fowels (1953) on Ponderosa pine and Jeffery pine, Shouldens (1961) on slash pine, Pitcher and Dorn (1972) on Black Cherry. They pointed out the relationship of seed size with the percentage of germination in most of the species. Schimpf (1977) studied seed weight of *Amaranthus reteroflexus* in relation to length of growing season and moisture. Jeglum (1979) studied effect of some seed bed types and watering frequencies on germination of *Picea mariana* and reported that nutrient supply, soil compaction, soil aeration and moisture supply were main influencing factors during germination and growth of its seedlings. Harper et. al. (1970) have reviewed ecological aspects of seed size, shape, number and correlated all these with safer site for germination, risk of predation, degree of dispensability, and availability of water. Venator (1973) working on *Pinus caribaea* correlated the date of germination with seedling height.

Harper et al. (1965) and Harper and Benton (1966) studied behaviour of seeds of *Plantago* species, *Bromus* species *Chenopodium album* and *Brassica oleracea* in soil and concluded that various macro environments provided on a surface act selectively on mixed seed population. The studies of Kandya (1978) and Kandya et al. (1978) on germination and growth of seedlings on *Pinus caribaea* revealed the occurrence of bigger seeds in drier areas due to greater endospermic nutrient pool and suggested that the seed weight can be used as a parameter for predicting seedling growth rate in nursery phase of development.

An understanding of community process like plant establishment, succession and natural regeneration needs knowledge of seed biology of plants especially while studying community regeneration in disturbed sites (Whitemore, 1983). Although very little information is available on seed physiology and ecology of tropical legume trees (Vazquez-Vanes and Orozwsegpvia, 1993). Existing studies have emphasized the importance of seed size and seed treatments for better germination. Usage of indigenous, potentially multipurpose leguminous tree species have been considered for agroforestry systems and reclamation of degraded lands in north eastern India where the forest is denuded due to shifting cultivation and commercial logging (FSI, 2001).

As far as seed biology of tropical plants especially trees is concerned, Troup (1921) and Champion and Seth (1968) have provided considerable information. Sen (1977) has reviewed the various researches on different aspects of seed biology of various species, especially the desert plants. Kamra (1974) has reviewed the seed problems of some developing countries in Asia, Africa and Latin America and suggested a number of national and international measures for better seed stocking and selection of suitable species for afforestation programmes. Germination studies have been performed in detail in few forest tree species of tropical and subtropical regions i.e., *Tectona grandis, Pinus caribea, Shorea robusta* and *Santalum album* etc. A large number of forest tree species in tropical regions have remained uninvestigated. Joshi (1961, 1962) studied germination behaviour of *A. latifolia* seed and correlated poor germination with the development of seeds. Kaul (1962) made studies on sixty eight species of Eucalyptus from different parts of Australia and Israel. They took into consideration the germination period, percentage germination and survival percentage and suggested that species with short germination period ranging from one to three weeks can be possibly used in arid zone afforestation programmes. Similarly Gupta et al. (1975) performed some preliminary test on fifty five tree species based on principle laid down by ISTA (Anon 1966) and tabulated rules for germinating above mentioned species.

Sharma (1977) studied the nursery behavior of *Diospyros marmorata* seeds, Verma and Sharma (1978) worked out seed collection of *Shorea robusta*, while Chauhan and Raina (1980) studied seed and seedling growth of Chir pine and found positive relationship of seed size with germination and seedling growth Baines (1980) studied seed germination of some important forest tree species in relation to different factors.

Seed size and weight are important characteristics associated with seedling vigour. It has been found that many plant species almost invariably produce larger seedlings when grown from larger seeds. This has been demonstrated by Hewston (1964). Small seeds have often been found to give poor plant establishment in field whereas; the larger seeds are the best. Harper (1967) has found during his experiments that differences in seed size and weight within a seed sample are reflected in the seedling size in wide range of plants.

Though the difficulties of grading the seed by weight is the major constraints in applying the method, however, the seed germination growth of the seedling and their fresh and dry weight increased with increase in the seed weight (Ponnammal et al, 1993; Quaraishi et al.1996). Since the survival and growth was positively related with the size of the seedlings (Singh et al, 1998). The large seedling raised from the large seeds will be given preference for plantation programmes, which may result in higher survival rates in plantations. On the other hand, Tripathi (1984) reported that big or large sized seed of *Anogeissus pendula* are unable to geminate while small seeds give better results.

Kandya (1978) has given a strong relationship of seed weight with several growth factors in the early development of *Pinus oocarpa* seedlings. Seed weight was also found to be most important factor affecting the size of one year old eastern white pine (*Pinus strobus)* seedlings. Pauley et al. (1955) found the fact that the heavy seeds germinated early, fastly and the resultant seedlings survived in large proportions than the light seeds. However, Pathak et al. (1981) found that in *Albizzia lebbek* the smaller seeds produced the healthiest seedlings as compared to large and heavy seeds, the same type of behaviour has been observed in case of several field crops by Wood et al. (1977).

Seed polymorphism has been reported in many plants particularly in leguminous herbs and tree species by Pathak et al (1981). Extensive researches on the effects of seed size and weight on the rate of germination and various aspects of plants growth have been carried out by Ghosh (1976), Singh (1972) and Thapliyal (1986). Size of the seed in many conifers has been found to have a controlling influence on their germination and the initial growth of resulting seedlings as demonstrated by Chauhan and Raina (1980) and A.K. Kandya (1978). The size and shape of the seed depends largely on the growth performance of the parent tree as well as environmental condition prevailing during the period of its seed production, was defined by Mayer-Mayber (1963). Kandya (1978) and Pawley (1955) reported that larger seeds are usually heavier because the size of the seed is a function of the endosperm quantity contained inside the seeds. Therefore fast germination of the seeds

and fast growth of the seedlings in the initial phase may be a reflection of the food capital of the seed. Small size seeds with low seed weight may be helpful in better dispersal, but are disadvantageous to the amount of food stored in it affecting germination as well as seedling growth in some cases.

Seed weight is affected by size, moisture content and the proportion of food content of the seed, justified by Justice (1972). Size usually reflects comparative higher nutrient pool and energy content of seed. Secondly, the quantity of the seed to be sown per unit area or per nursery bed is fixed by the seed size. Hence, smaller seeds usually result in a high density of seedlings per unit area as against a low density by sowing large sized seed of similar sample weight in the area. Sowing of mixed or upgraded seeds of a species give rise to an uneven density of stocking in nursery bed, which in turn develops heterogeneity in vigour and the size of the seedlings.

Physical characteristics of many seed varieties in various plant species have been studied by number of workers like Rathore (1968) Athya (1980) and Jain (1962). Their study aims to investigate the growth pattern of seedlings in the nursery and to work out the trend of correlation between different parameters of seedling and seed characteristics. Khan (1977) have emphasized that viability and germination are the important factors for determining vigour of seedlings in the nursery.

Mayer et al. (1963), Singh (1963) and Singh (1968) have stated that seed morphology is a main character in assessing the extent of dispersal of seeds. The effect of seed grading by size on germination and growth of pine seedlings was reported by Ghosh et al. (1976).In comparison to smaller and big seeds, medium sized seeds have higher mean of daily germination. The effect of seed size on germination in *Shorea robusta* was reported by Champion (1932). Vanangamudi (1988) have quoted that plant height is directly proportional to seed size. Such relation of seed size with seedling growth in different tree species have been studied by number of workers *viz* in species of *Pinus roxburghii* (Chauhan and Raina, 1986), *Morus alba, Quercus rober* and *Q. velytira* (Kotwal, 1927) and *Pinus oocarpa* (Kandya, 1978) and reported significant co relation between germination rate and seedling size. Chauhan (1998) has made the meterological analysis of 20 seed sources of *Bauhinia variegata* and studied their morpholological variations under nursery conditions and reported that medium sized seed grade gave higher values of initial germination, total germination and germination values for all species. Kandya (1978) reported that large seeds are usually heavier because the size of seeds in fact is a function

of endosperm quantity contained inside the seeds. Gupta et al. (1983) reported that the size usually reflect the comparative nutrient pool and energy of seed which effect the further growth and development of seedlings. Bhardway (2001) concluded that larger seeds were found to germinate faster and more completely than the smaller ones and produce seedlings with greater initial growth.

Das et al. (2002) have thrown light on effect of seed grading on germination pattern of some multipurpose tree species of Jammu region. The results have shown that medium size seed grade gave higher values of initial germination, total germination and germination values for all species studied except in case of *Robinia pseudoacacia*, where comparative balance of total seed germination was recorded for small and medium sized seed grades. Mann et al. (2000) has done great deal of work on physiological aspects of seed source variation on seed germination of *Quercus leucotricophora*. They found that provenances differed from each other in mean seed weight germinability of seeds and seedling growth. However, differences were significant more in rate of germination than total percentage. Baki (1972) have also studied data regarding seed weight in relation to different environmental condition and concluded the same fact. Chauhan (1988) have thrown light on effect of seed weight on germination in pine and recommended grading of seeds before sowing to obtain uniform stock in all the species.

Devarnavadgi and Murthy (1995) have observed the performance of different tree species on eroded soil of northern dry zone of Karnataka and found that larger seeds were found to germinate faster than the smaller ones and to produce the seedlings where initial growth was greater. Dwivedi and Dyuryagna (1996) have done great deal of work on effect of ecological conditions on morphological variation of seeds genus *Aconitum attai* and observed the same results as depicted earlier. Kataki et al. (2001) have studied on variability of pod and seed traits in various species and concluded that pod and seed size has marked influence on germination.

Abd-Al-Haki (1994) have studied certain aspects of seedling emergence of *Dendrocalamus strictus* in relation to seed size and weight parameters and concluded that seed grading before sowing is an efficient and successful method to obtain better yield.

Rai et al. (2001) have recorded comparative values of total seed germination for small and medium sized seed grades and concluded the importance of medium sized seed for germination as compared to small sized seeds. Jagdish (1983) has studied relationship between seed size and seed quality attributes on *Helianthus anus*. Levitt and Loicharich

(1963) have studied response of plant to environmental stresses. Kumar et al. (2001) have studied effect of pod and seed size on germination parameters of *Albizzia lebbeck.* It was found that the size and colors have marked influence on germination. Pod size of 8-16 cm length and pod colors of grayed orange group gave highest germination. Similar seed weight of 6-12 g and seed colours of brown group gave highest germination parameters.

Nautiyal and Rawat (2000) have thrown light on the physiological aspects of seed source variation in certain species and concluded that provenances differed from each other in seed weight and size parameter. Singh et al. (1999) have studied species density and soil variability in *Shorea robusta* considering seed size and weight parameters. Unalcin (1979) William (1993) and Vakshasya et al. (1992) have experimented on data relating to seed size and weight parameters and found that larger and heavier seeds gave better response as compared to smaller and light weight seeds.

The results of present study are confirmed by findings of similar studies made earlier in different plants by workers namely Pathak et al. (1981), Gupta et al. (1963) and Singh et al. (1981) who reported that the germination, root length, collar girth, shoot length, fresh weight and dry weight of the seedlings increased with the seed weight. The higher growth could be the attribute of large seeds having higher food storage in comparison to the less potential seeds having lower food storage, though the difficulties of grading the seeds by weight are the major constraints in applying the method. However, the seed germination, growth of seedlings and their fresh and dry weight increased with the increase in seed weight as stated by Ponnammals et al. (1993) and Quraishi et al. (1996). Singh et al. (1993) concluded that since the survival and growth was positively related with the size of the seedlings the large seedlings raised from the large seeds will be given preference for plantation programme which may result in higher and early survival rates in plantations.

Jagdish and Shambulingappa (1983) reported high positive correlation between seed size and germination, vigour and highly negative correlation between electrical conductivity and seed size in sunflower Bangarwa (1993) suggested that large seed size having low electrical conductivity is a simple measure for higher seed ability, germination storability and seedling vigour in *Dalbergia sissoo.* Observations made by Yadav et al. (1986) on *Dalbergia sissoo* revealed that seed weight which had significant positive correlation with seed vigour, also have significant positive correlation with seed viability, germination percentage, storability and vigour index and significant negative correlation

with electrical conductivity. According to Lindgren (1982), Campbell and Sorenson (1984) in the primary selection of seeds fractionation on the basis of seed size is a common practice used to obtain uniformity in the seedling size of *Albizzia procera*. Dunlop and Barnett, (1983) stated that reports concerning the effect of seed size on germination, early development and physiology of woody plants are inconsistent. According to them a positive correlation was observed between seed size and seedling size. Seed weight has been reported to be a useful criterion for early selection of seed source (Khalil, 1986) while seeds size and colour are important markers for identifying superior plant population (Harper et al. 1970) .The correlation of pod length with pod weight and seed weight per pod and number of seeds per pod were observed by Sharma et al. (1994) for *Prosopis juliflora* and concluded that high phenotypic and genotypic variability in pod, seed and germination characters existed within population for best result.

Extensive research on seed size effects on various aspects of plant growth pertaining to field crops has been carried out with the positive relation between seed size and the vigour of the plants (Chauhan and Raina, 1980) Differences in seed size within a seed sample are reflected in riddling size in wide range of plants. Babeley (1985) found that size of seeds in many conifers have been found to have a controlling effect on their germination and in the initial growth of the resulting seedlings. Krishnapillai et al. (1982) concluded that generally large seeds were found to germinate fast and more completely.

Seed germination and seedling performance of few species has been found to be affected by seed size. (Pathak and Gupta, 1984; Ponnammal el al. 1993 in *Hardwickia binnata*. Arjuan et al. (1994) in *Pongamia pinnata*, Yadav, et al. (1998) in *Dalbergia sissoo*, Gunusedaran and Krishnaswamy, (1999) in *Eugenia caryophllata*, Indira et al., (2000)in *Tectona grandis*, Girish et. Al., (2001) in *Sapindus trifoliates* and Dar et al. (2002) in *Albizzia lebbeck*. Acacia catechu and *Pinus roxburhi*i reported that larger size seeds showed better performance than small or medium size seeds. However, Ghose et al. (1976) and Srimathi et al. (1991) reported medium sized seeds performed better than small and larger seeds in germination and vigour test in case of *Acacia mellifera* and *Pinus roxbughii* respectively but Agboola (1993) reported that seed size difference had no effect on the growth performance of seedling raised from *Cieba pentandra* and *Leucaena leucocephala*. Similar investigation were recorded by Indira et al. (2000) in *Tectona grandis*.

Gupta et al. (1983) reported that the initial field emergence and growth rate for the seedlings of *Leucaena leucocephala* were found higher in the larger seeds. Large sized and

light weighted seeds of *Lagerstroemia parviflora* are superior as far as their germinability is concerned (Shukla and Ramakrishna 1981). On the contrary, Ghosh and Sharma (1976) depicts that medium sized seeds gave significantly higher mean total germination percent and plant percent as compared to the large or small sized seeds of *Pinus* species. Again, Kandya (1978) reported a strong relationship of seed weight with several growth factors in the early development pf *Pinus oocarpa* seedlings However, an unusual behaviour has been reported, whereby, the smaller seeds of *Albizzia lebbek* gave faster moisture uptake and emergence but low percentage of germination as compared to the large and medium sized seeds (Pathak, Gupta and Debroy, 1981).

Sharma (1977) studied the nursery behaviour of *Diospyors marmorata* seeds, Verma and Sharma (1978) worked out seed collection of *Shorea robusta* seed, while Chauhan and Raina (1980) studied the behaviour of seed and seedling growth of Chir pine and reported positive relationship of size with germination and seedling growth. Baines (1980) studied seed germination of some important forest tree species in relation to different factors.

Pandey et al. (2002), Parmeshwari et al. (2001), Sharma et al. (2001), Khera et al. (2003), Khan (2001), Harakumar et.al. (2000) have also given their remarkable contribution in the field of seed germination and seedling growth of their respective species. Ali and Kamaluddin (1997) have studied bearing of hot water treatment on seed germination and seedling growth of *Albizzia procera.* Kumar (2007) has observed the effect of seed size on germination and seedling performance during storage of *Azadirachta indica* seeds.

Siddiqui and Seemi (1999) have worked on seed size variation and its effects on germination, growth and seedling survival in *Acacia nilotica.* Srimathi and Surendran (1991) have observed the effect of seed coat color and seed size on seed germination in *Acacia melifera* and found that large sized and heavy seeds gave better response to germination and seedling growth as compared to light weight seeds.

Vyakaralal et al. (1992) have studied the effect of grading on seed quality in *Tamarindus indica.* Sharma et al. (2004) have studied the effects of seed size and pretreatments on germination of *Albizzia lebbek.* Bohara et al. (1990) have studied effects of seed size, pretreatments influence of seed weight and improvement of germination of some forest species by method of breaking seed dormancy and given their respective results.

Bagchi and Rawat (1990), Chopra (2002), Kaushik et al. (1996), Krishnan (1996), Thakur (2002), Kandya (1989), Gopikumar (2002), Bhattacharya and Saha (1990) and Masilmanni (2003) have studied provenance variations in seed germination and seedling growth in their selective forest tree species and have given remarkable contribution in the field of seed science and technology.

Neeta Mutha et al. (1963) have stated that viability is the condition of seeds in the sense of being capable of growth and survival. Schopmeyer (1974) defined seed viability is the potentiality of seed to germinate. Bonner (1974) defined seed viability as the state of being capable of germination and subsequent growth and development of the seedling. Results envisaged by Kandya (1978) Kumar (1979) Chauhan and Raina (1980) and Pathak et al. (1981) stated that large size seeds of almost all the species enhanced germination and produce vigorous seedlings.

Mayer and Shain (1974) have suggested that environmental factors control germination by action on specific sites of metabolic sequence Bewley and Black (1978) have called seed as a dispersal unit proofed with reserve food which sustain the young plant until a self sufficient autotrophic organism can be established Baldwin (1942) looking unto possibility of growth of plants proposes that it is an abstract term referring to the potential capacity of seed to germinate. Agarwal (1980) defined the term viability as the ability of seed to live grow and develop.

According to Hatano and Asakawa (1964) for testing seed quality, there are the methods of estimating seed germinability with or without actual germination. In many tree species seeds often germinate slowly and unevenly. Therefore, methods not involving actual germination have been especially helpful for testing the viability of the tree seeds.

Villiers (1978) have illustrated that the cutting test is the simplest among all the viability tests. Earlier attempts to get a rapid estimation of the germination capacity of seed were through the cutting test. The seeds were simply cut opened and the number of empty ones was recorded. This gives a fairly accurate measure of germination expectancy when the seeds are fresh or of high quality.

Hatano and Asakawa (1964) have illustrated that biochemical staining tests have shown that the viable seeds are visibly stained where as the nonviable seeds are not. According to Hasegawa (1936), biochemical method was first established with tellurium salts and Eidmann (1964) has stressed on establishment of selenium salts. Later on Kuhn and Jerehal (1941) have valuated the importance of tetrazolium salt as an excellent

indicator of reduction in biological materials. Since then, the use of 2, 3, 5, Triphenyl Tetrazolium Chloride (TTC) as a useful viability indicator has been reported by several workers namely Parker (1953) and Asakawa and Yananigasawe (1953).

Moore and Smith (1957) have found that tetrazolium salts are more stable than some of other dyes (Indigo Carmine, Bismarck Brown, Methyl Blue, Malachite green etc.) and can work even under aerobic conditions. In addition to imparting permanent colour, the tetrazolium salt has a low toxicity both for the plants and for the few organic compounds that can remain visibly closed in their reduced state. In the presence of viable tissue, the almost colourless tetrazolium salt is transformed by enzyme as an insoluble bright red Tripheryl Formazon. A description of the general technique of tetrazolium testing has been provided by Moore and Smith (1957). According to Heydecker (1972) the viability test is effectively a death test. However, it is widely accepted that loss of viability is almost the last stage of detoriation, the final catastrophe which is provided by more suitable changes.

Seed viability is determined by tetrazolium chloride test by various workers showed good relationship with viability and germination. Mukherjee (1956), Unalcin (1979), Kandya and Babeley (1984), Moore (1985) and Buszewinz and Holmes (1957) considered embryo with about 1/6 of the unstained area as viable. Lakon (1950) also emphasized the importance of necrosis on the endosperm in the tetrazolium test. Bulat (1957) considered those seeds viable which were having completely stained embryo and endosperm. Neljeebo (1925) studied that indigo carmine stains dead or dying tissue of the embryo readily but leaves the living tissue unstained. Saha et al. (1950) have reported several factors for the short viability period of the seeds of *Shorea robusta*; similar results have also been obtained by Yadav et al. (1998) in the seeds of *Chloroxylon swieietenia* (Bhirra).

Babeley and Kandya (1986) have used Triphenyl Tetrazolium Chloride for rapid testing of Viability in *Lagerstroemia parviflora* and many more plant species. Gupta and Raturi (1975) has performed tetrazolium testing on six Indian forest tree species and found the science behind storing seeds for a long time. Generally the colder the storage, the longer the viablility of seed. Gera et al. (2003) have evaluated some cost effective containerized nursery technologies for storing seeds for longer time viable. They have suggested improved quality of polybag plants and stressed on the use of MAI beds for nursery and germination. Gurudev (1994) has experimented on seed storage and viability of *Toona ciliata* and *Shorea robusta* and found that moisture is the other key factor for keeping seeds viable for longer time.

Van (1986) has studied on the effect of air temperature, oxygenation treatments and low storage temperature on seasonal germination response of *Lycopersicum cordifolium* seeds. Anita and Reddy (1993) have studied hormonal response and seed viability of *Porters coarctrata*, a brackish water species. Similarly, Ebofin et al. (2002) has reported moisture to be the key factor for the short viability period of seeds of certain species.

Seed germination is a well programmed process controlled by both the internal and external factors. Seeds do not resume physiological activity until they imbibe certain amount of water (Come and Tissaou, 1973). According to him water uptake by seed is a prerequisite of germination Harper and Benton (1966) assumed that the failure of living seeds to germinate or the delay in the germination is due to insufficient delayed hydration of the seed. According to Yadav and Mishra (1982) different duration of imbibition affect the germinative capacity of forest tree seeds. Kocchar and Garg (1983) during their experimental studies concluded that continued water stress inhibited seed germination and further observed completely at 5 bar water potential in winged beans. The germination percentage declined as water stress becomes higher.

According to Hatano and Asakawa (1964) seed coats have long been considered to be a kind of barrier to water absorption. Such type of impermeability of the seed coats to water can be overcome by increasing the absorptive power of the inner tissues which is generally brought about by pre- chilling or by scarification. Recently effect of different methods of scarification on seed germination has been studied in various plants by number of workers namely Verma and Tandon (1984) and Hussain et al. (1988).

Mechanical scarification and pre treatment with concentrated H_2S0_4 and HNO_3 stimulated germination in *Acacia fernesiona* (Gill, Jagade et al. 1986) and Rai and Nageverni (1988) during their experimental studies found that in *Ficus benghalensis*, F. *glomerata, F. myaorensis* and *F. religiosa*, soaking of seed for 10 minutes in hot water at 60^0 C gave the highest germination percentage. Vasistha and Soni (1988) stated that sulphuric acid treatment has positive effect on germination of *Trema politician* seeds. Concentrated Sulphuric acid, hot water treatment and the mechanical scarification were found to be beneficial in breaking the seed coat dormancy and enhancing the germination percentage of seeds of *Prosopis juliflora* (Babely, 1985). For best germination in Teak soaking of the seeds for 48 hours in water and then followed by an alternative drying and soaking (12 hours each) for 21 days is recommended by Negulube (1988). Kandya and

Babeley (1985) reported that hot water treatment was found to give a very good germination and also the higher values of germination in *Leucaena leucocephala* seeds.

Babeley and Kandya (1985) while working on suitable pretreatment for seeds of *Acacia catechu* recommended that when seeds of this species treated with concentrated Sulphuric acid for 10 and 15 minutes gave better results. They observed that mechanical scarification (foiling) and treatment of seed with concentrated Sulphuric acid produced a handsome number of vigorous seedlings in *Cassia fistula.*

The germination of most of the species is adversely affected in saline soils (Hamson and Sampson, 1990 and Molibasi, 1993). Germination percentage of unsoaked and presoaked seeds showed a linear decrease in germination with increase of salt concentration of the germination medium. Decline in germination due to excess of salts in the environment is reported for both glycophytes (Bhumbla and Singh, 1965 and Munich and Jindal, 1983) and halophytes (Aronson, 1985). Finally it may be suggested that the harmful effects of salinity stress in Su-Babul could be asseverated by presoaking treatment. Such a beneficial effect of treating seeds of several herbaceous plants with osmotic solutions, salts or neutral polymer for improved performance has been reported by several workers (Singh and Singh, 1991).

Moist cold stratification is commonly used to break dormancy or improve germination for Pine seeds as illustrated by Schubert and Adams (1971). Instances where the germination of seeds has been adversely affected by hot or boiling water treatment have also been reported by Delouche (1964) Bewley and Black (1985), Cooper (1986), Kumar (1990), Sharma (1997) and Chacko and Pillai (1997) etc. The reverse breakdown of germination mechanism in seeds when soaked in boiling water may be due to lethal action of boiling water (100^0C) on enzyme activity responsible for initiating germination percentage and germination energy percent. However with the increase in exposure time of seeds in concentrated H_2SO_4 for 5 minutes, there was slight decrease in the values of their germination percentage. The concentrated H_2SO_4 might have exerted its dehydrating action upon the seeds of this species and produced best results in case of germination values and germination rate index, despite decrease in the values of germination percent and the germination energy percent. Therefore, it can be easily said that long exposure to acids is not recommended in certain species. Harrington (1916) found that the long time acid treatment of seeds leads to poor germination. Gupta and Raturi (1975) found that the seeds stored at room temperature lost their viability due to activity of mycoflora present inside

the seed. Almost identical findings were reported earlier by Ahmed et al. (1993) in *Toona ciliata* seeds, and Suman (1996) who studied *Populous ciliata* seeds for storing effect. They found that decrease in seed germination was more pronounced during first three months of storage period.

Sah and Singh (1995) have studied the effect of temperature and storage on germination in *Populus.* Sasaki (1980) have worked on storage and germination of dipterocarpus seeds. Similarly, Sakhibun (1981) have worked on storage and viability of Hevea seeds. Kumaran (1996) on Neem seeds, Murugesh (1995) on Teak seeds, Nayal (1999) on *Azadirachta indica* and *Grewia optiva* seeds, Simak (1973) on *Pinus sylvesteris*, Song (1984) on *Hopea bhainenansis,* Purohit (1997) on storage of *Albizzia procera.*

Variation in *Albizia lebbeck* seed sources could be due to the fact that the species grow over a wide range of rainfall, temperature and soil type. Such variations in relation to habitat have also been reported by Kumar et al. (2004), Todoria et al. (2004) in *Acacia nilotica.*

Krishnapillay (1996) have created alternative methods for storage of orthodox and recalcitrant seeds which have been classified on the basis of their response of water. The orthodox seeds are usually dormant and can retain viability even at very low moisture content. Similarly, Ezumah (1986), Dent (1948), Dass (1971), Devagiri (1998) and Dabral (1976) have worked on physiological processes of forest tree seeds during seed storage and germination and found that decrease in seed germination is more pronounced during first three months of storage period. Effect of tree age class and dormant behaviour of seeds of some important Himalayan trees was studied by Sharma et al. (2002) and found an increase in period of viability on account of storage at freezing temperature probably due to relative humidity maintenances and temperature. The important factors which determine the viability of seeds in storage system were seed moisture content and temperature. Seed stored at room temperature lost their viability rapidly as compared to those in refrigerator and thus affecting their longevity.

Similarly, Phartyal et al. (2001) have investigated on storage protocol of *Ulmus wallichiana* seeds and its effect on equilibrium moisture content on seed viability and vigour and reported a positive response of low relative humidity and low temperature on viability and germination percentage as well.

Singh (2000) has experimented on breaking of dormancy of seeds of some of the important forest tree species by application of plant growth regulators and was successful

in breaking early dormancy in seeds of certain species. Song et al. (1984) have performed a detail study on the principal storage conditions of *Hopea bhainanansis* seeds and concluded that any seed which requires the onset of germination has to fulfill certain conditions which are different from those required for continued development of seedling area, are said to be dormant. Crocker and Barton (1953) have pointed out that in continuance of any plant species, seed dormancy is a desirable trait, and such seeds not only remain viable for long time, but under natural conditions individual seed become permeable at different periods.

According to Khan (1977) seed dormancy is a device for optimizing the distribution of germination of species and its importance is best seen in ecological context. Nikoleava (1977) suggested that dormancy allow most of the plants to survive during adverse seasonal conditions in the soil. Hartman and Kaster in 1976 opened the fact that hard coated seeds if kept in non sterile moist warm medium for several weeks, get soften due to micro organism action. Milat-E-Mustafa (1989) and Bahuguna et al. (1987) have worked on seed germination and seedling growth of *Albizzia lebbek* and found positive effect of presoaking on these processes rather than unsoaked seeds. Khasa (1992) observed hasten germination in *Casuarina equisetifolia* on chemical treatment. According to Khan (1977) viability and germination are important factors which control the vigor of seedlings in the nursery.

According to Sahu et al. (1995) orthodox and recalcitrant seeds have been classified on the basis of their response of water. The orthodox seeds are usually dormant and can retain viability even at very low moisture content. Kid and West (1918, 1919) found that soaking of seed has a profound effect on the subsequent growth of the plant. Tourney and Durland (1923) studied soaking effect on a number of coniferous seeds of upland species before sowing and found that soaking for more than 3 to 5 days were generally injurious.

Orphan and Heydecker (1968) have suggested that soaking injury is caused by deficient oxygen supply to the interior of the soaking seed as cavity between the cotyledons is flooded with excess of water. Ghosh et al. (1974) studied that soaking of seed for 18 hours at room temperature is best suited to *Pinus patula*. Marunda (1990) has reported that treatment of seed with weaken the seed with H_2SO_4 weaken the seed coat which leads to expansion of embryo, thereby leading to increase in rate and percent of germination. According to Dent (1948) Neem can be easily reproduced artificially either by direct sowing or seedling transplanting or stump planting but the biggest problem in raising seedling is the short viability of neem seeds. The seeds lose viability within a few days of

collection and cannot be stored at low temperature. The seed viability starts detoriating after two weeks. Maithani et al. (1989) have reported that physiologically mature seeds attain maximum germination capacity to remain viable for longer duration.

Maithani et al. (1989) further argued that fibrous hard and yellowish stage of fruit is detectable index of maturity and may be recommended for bulk collection. According to Smith (1989) green cotyledons of Neem will germinate but brown or yellowish would not germinate. Various authors have worked on seed viability of neem seed, Maithani et al. (1989) reported that the viability of neem seeds can be best maintained in well aerated containers at room temperature or at 15° C up to 6 months. Seeds dried in sunlight in glass house for 3 days and stored at 15° C in cotton bags retained viability for more than four months with 62% germination capacity

Since temperature and substratum plays a very significant role during the process of seed germination. Seeds of some species germinate better at constant temperature and others at alternate temperature (Bonner, 1972 and Kumar and Tokyo, 1996). Therefore, experiment was performed to observe the significance of this factor to determine its optimum temperature requirement in better germination of seeds of *Azadirachta indica.* The dried seeds were stored at room temperature in air tight cotton bags. Germination tests were conducted in laboratory, as per the procedure recommended by international seed testing association (Anon, 1993). Four replicates of 100 seeds each were sown in petriplates on germination paper moistened with distilled water. The petriplates were placed in seed germinator. The mean daily germination (MDG) was calculated to determine the speed of germination according to the procedure done by Tompsett (1985). Results envisage that temperature is an important factor for seed germination because various biochemical reactions in food reserves of the seed depend upon temperature. The importance of constant and alternating temperature and other environmental factors for the germination of seeds in the laboratory and in the field has been discussed in detail by Pollock (1972), Hegarty (1973), Heit (1974) and Kumar and Bhatnagar (1973).

The germination percent was greatly influenced by temperature. Gupta and Kumar (1977) studied the effect of temperature and moisture on germination of *Dendrocalamus strictus* and reported that 30^0 C temperature and 50-75% moisture level was optimum for better germination. In a separate study, they also reported that in *Dalbergia sissoo* seeds placed at room temperature of 20^0 C between germination (Towel) paper showed better germination (Kumar and Bhatnagar, 1976). Chaturvedi

(1998) also studied the temperature effect on selected forest tree species of tropical dry deciduous forest of Central India and found similar results Anju et. al. (2000) studied the effect of different temperature and substrate on the germination of Kadam *(Anthocephalus chinensis)*. Similar results have been found by Nikhil et al. (2001) on seed germination in certain seed species.

Under unsuitable temperature the seeds of any species fail to germinate or they show poor germination. Most of the previous report on seed germination by Wright (1931), Nizuma (1936), Quintivan (1966), Ellens (1967), Datta (1968), Tissaouri (1973) and Maguire (1973) described merely the effect of low, high or optimum temperature on seed germination of some species. Thompson (1974) in his study on seed germination in four species has observed beneficial effects of fluctuating temperature on them. Kumar and Bhatnagar (1976) studied the effect of temperature and substratum on seed germination of *Dalbergia sissoo* and concluded that the seed placed at a temperature of 30°C in between germination paper shown better germination. Gupta and Kumar (1977) reported the 30°c is the ideal temperature for the germination of *Dendrocalamus strictus* while; Kumar (1980) found increase in rate and percentage germination in *Pinus contorta* with rise in temperature of 10 to 20°C and 20-30°C. Santra et al. (1981) reported low temperature to be favourable for germination of *Bidens pilosa* seeds.

According to Chaturvedi and Bajpai (1999) the effect of different light conditions on germination and seedling growth of some selected forest tree species *viz. Bridelia retusa* (spreng), *H. antidysenterica* (Wall) *L. Parviflora* and *W. tinctoria* (R. Br.) seeds were sown in earthen pots filled with a mixture of garden soil sand and decomposed manure in 2:1:1 ratio. After sowing of seeds, three light condition *viz.* semi shady, shady and full sunlight were considered for the experiment and observations were made at definite intervals. The above studies showed that root length was found maximum under semi shady condition in *Bridelia retusa* and *H. andtidysenterica* and in *L. parviflora* and *W. tinctoria* was higher in full sunlight conditions.

Tewari et al. (2000) studied on the effect of different light conditions on seedling growth of some leguminous forest tree species. Borthwick (1954) has studied on action of different light condition on lettuce seed germination and found that semi shade condition is best for lettuce seedling propagation. Bakshi (1952) has studied the effect of preliminary period of darkness on the percentage of seed germination of *Anthoshilus ericopephalus.* Bore et al. (1978) have studied the effect of different temperature and light conditions on

germination of *Papaver sominiferum*, *P. bractatum* and *P. oriental.* Campbell and Sorenson (1979) have given a new basis for characterizing seed germination on the basis of different condition and containers used in nursery techniques.

Champion (1934) has experimented on seasonal progress of night growth in tree during different season and at different temperatures. Mc Gee (1976) has sorted out difference in bud break between shade grown and open grown Oak seedlings. Vyas Saroz (1999) have studied the effect of shade on the growth of *Cassia angustifolia.* Saju (2000) has studied the effect of shade on seedling growth of *Grevillea robusta*, *Tectona grandis* and *Allianthus tryphysa* in the nursery.

Kozlowskii (1955) has studied on tree growth action and interaction on soil and others factors and also given a review on seed germination and seedling development on growth and development of trees. Kulkarni (1981) has experimented and observed polyembryony in the genus *Santalum album.*

Blackman and Wilson (1951) and Blackman et al. (1955) reported that light act as limiting factor in the growth of herbaceous plants. The influence of light has a great significance on the growth of seedling as it is the universal source of energy which is fixed by them in the form of chemical energy by photosynthetic carbon assimilation for use in various life processes. Shirley (1929) studied the influence of light intensity and quality on the growth of plants. Loach (1957) has worked out tolerance in tree seedlings. Robert (1971) found that in Red Oak (*Quercus rubra* L.) the tallest seedlings grow in 30% light. Robert (1971) found that the tallest seedlings of *Quercus rubra* L. in 30% of full sunlight, except the dry weight were comparatively lesser than that of absolute light. Similarly, Pathak et al. (1983) during the study of *Leucaena leucocephala* Lam. found that the seedlings raised under 45% light conditions showed better height and greater dry matter. Many plant species are shade loving or light demanding during their early phase of life. Recently, many other workers have also investigated on the significance of light in many other plant species namely Martin, (1968) Meher-Honji (1973), Williams (1970), Mishra and Benergi (1995), Nanhorya and Srivastava (1999) and Leyton et al. (1957).

Many workers like Troup (1921), Bhargava (1951) and Mathur (1956), have indicated essentiality of partial or lateral shade in the earlier stages of seedlings of certain species which protect them from drought. While, others species which showed better growth in full sunlight may be light demander during their early phase of growth.

Ouantivam (1966) has found relationship between temperature fluctuation and the softening of hard seeds of some legume seed species. Srivastava and Kooner (1978) have sorted out the effect of temperature on the physiology and biochemistry of germination of seeds of *Phaseolus aureus*. Toda (1951) has used boiling water as a technique to hasten germination of *Robinia* seeds. Vanderveen (1951) has studied the influence the daylight on the dormancy of some species of genus *Populous*.

The effect of light on germination has been known to vary considerably with seeds of different species. Some seeds germinate after being given a brief illumination, while some are indifferent to the presence or absence of light during germination (Schimdt, 2000 and Luna and Chamoli, 2008) in these cases, presence or absence of light could not affect the germination. The present study showed non photo dormancy of Neem seed. Seeds with photo dormancy only germinate in the light with a high red/far red ratio eg. white sunlight (Schimdt 2000, Khan et al. 2002 and Kumar et al. 2007).

Effect of alkalinities on seed germination and seedlings growth of important arid trees has been demonstrated by Srinivasu and Tokyo (1966). Ali et al. (1979) have studied effect of light intensity, air and soil temperature on root regeneration potential of *Pinus caribaea* and *P. kesiya* seedlings. Shive (1916) has illustrated the effect of salt concentration on the germination of seeds. Shelhevet and Bernstan (1968) have studied the effect of vertically heterogenous soil salinity on plant growth and water uptake.

Irrigation is the most important medium necessary for life; Moisture appears to the most important functional constituent of biological cell effecting almost all the vital physiological process. It is indirectly related to the cell division and various other functioning processes. In soil a balance content of water allows a suitable level of soil air. It indirectly controls the growth performance of seedlings.

A number of studies on soil moisture water supply and aeration in relation to seed germination and growth of seedlings species has been carried out by many workers. Stansky and Wilson (1967), Herbal and Sosebee (1969), Dickson (1972), Roger and Tanaka (1976). While, Seth and Srivastava (1972) pointed out a close relationship among water supply and nutrient update of plant in Sal seedling. Jeglum (1979) studied the effect of seed bed types and watering frequency on germination and growth of black spruce. Singh et al. (1989) studied the effect of irrigation on fresh and dry matter production in summer forage. Soil is an important factor for the establishment and survival of a species. Root system of plants as well as soil is equally important since soil is the medium in which

roots grow, anchor the plants and from which the plants drew water and nutrients as such the importance of soil properties in the plant environment is of great significance. The growth and quality of forest (whether naturally occurring or artificially created) depends basically on the physical and nutrient status of the soil. Work on seedling establishment, survival and soil characteristics in relation to seedling growth is scarce. However, some preliminary work was done by Troup (1921).

Anthony (1989) has observed poor growth of *Pinus carabaea* seedling in clay soil due to decreased root respiration in higher water holding as compared with peat soil. Further Eaves and Payne (1969) have identified the importance of a number of soil factors upon the growth performance of root at early stages. Seth and Srivastava (1972) have also studied importance of different soil factor in relation to root development. He reported that the garden soil and sand mixture (2:1) and sand humus mixture (1:1) appeared to be most satisfactory potting media for the growth of *Pindorosa rupa.*

Eaves and Payne (1989) have observed that soil texture has profound influence on root growth particularly at seedling stage. Different ratio of soil mixture has been recommended by various workers for different species (Evans, 1983, Bahuguna and Lal 1990 and Roy, 1986).

Requirements of optimum container size depends on factors like type of species, growing density, type of growth media, length of growing season and size of seedling desired for planting (Jinks, 1994 and Sharma 1996). Sand gave significantly poorer germination as compared to others. Similar results have been documented by Kumar and Bhatnagar (1976) in *Dalbergia sissoo*, Ghyare (2005) in *Albizzia lebbeck*, Shringirishi et al. (2001) and Kumar et al. (2007) in Neem and Ramchandra (1996) in *Acacia catechu.* Significantly higher germination has been observed in lab condition on blotting paper as compare to sand in *Terminalia mysiocarpa.* and *Adathoda vasica* (Bahugana et al. 1987 a,b), *Alnus nepalensis* and *A. nitida* (Thapliyal and Rawat, 1991) and *Messua ferrea* (Khan et al., Bahar and Singh, 2007) the increase in height and diameter growth, biomass and survival on addition of forest soil has been reported by Dadhwal and Singh (1992), Dadwal et al. (1993), Paul Swamy et al. (1996) and Pawar and Bhardwaj (2000). Verma et al. (2001) reported the effect of forest soil based potting media on growth performance of different tree species under nursery condition.

Apart from soil, fertilizers also exert a pronounced effect on the growth of root and shoot in certain species (Swetzer and Nelson 1963). The improved mineral nutrition

during establishment may increase root growth of seedling (Roy et al. 1984). However, the optimum requirements for different fertilizers vary with the species as well as prevailing soil fertility level (Ginwal et al. 2001). Sabale et al. (1995) have discussed the effect if different potting media on germination, propagation, growth and moisture content of *Mentha longifilia.* More recently Tiwari et al. (2001) recorded the effect of different potting media and concluded that the best growth media was soil and sand (S_2) in equal proportion for all selected species. Better results in S_2 was due to good aeration and low moisture content

Potting medium is the most important input for containerized seeding production. It is responsible for healthy and uniform seedling production. Apart from the selection of proper ingredients, it is necessary to maintain the porosity of the potting mixture so that proper development of root takes place. (Srivastava et al., 1988). The media should be rich enough to sustain seedling for about 90-120 days. A good potting medium is characterized by light weight, friability, easy blendability, good water holding capacity, drainage, porosity, slight acidity, low bulk density free from fungal spores and insects and low inherent fertility etc. (Chakravarthy et al., 1998). The primary ingredient for potting media in India is compost and high quality compost can be made from vegetative waste particularly forest weeds (Jones, 1998). Preparation of suitable potting medium includes standardization of texture and nutrient status. There can be no standard mixture because the compost varies from nursery to nursery. As a result site and species, specific work is required to be done for developing a proper potting mixture.

According to Gera et al. (1999), *Dalbergia sissoo* is one such species where edaphic factor has to play a profound influence on its distribution rather than climatic factors. The tree comes up well on new sandy alluvial and well drained soils. Its good growth is noticed in porous and well aerated soils with adequate moisture. It prefers porous soil and sand and abort stiff clayey soils. A similar type of potting media would be helpful for the production of quality seedling in nursery which the experimental results also confirm.

The type of soil mixture affects the growth and quality of seedlings of various tree species in the nursery (Bahuguna and Lal, 1990 and Lenuwal and Dhawan, 1991). Among all the potting mixtures seedlings of *Dalbergia sissoo* indicated higher growth and dry weight in the potting mixture of soil sand, sand and FYM in 1:2:2 and 1:2:1 rate. It was also observed that seedling growth increased in all the combinations of FYM, soil

and sand. The water holding capacity of FYM is always greater then the sand and soil individually or in combination moreover the FYM regulates nutrient uptake, improve plant yield and physical status of soil (Lal and Mathur, 1989 and Kaberathunma et al., 1993). Thus the increased level of FYM in the potting mixture favours the growth of seedlings. This is in conformity with the findings of Bahuguna and Lal (1990) and Nautiyal et al. (1995) who also observed better growth of seedlings on the addition of FYM in soil mixture.Yadav et al. (1982) have also attributed higher water holding capacity to higher growth of *Tectona grandis,* on increasing the quantity of FYM in potting mixture beyond 1:2:2 ratio of soil, sand and FYM was not much beneficial for the plant growth which can be attributed to the reduction of water holding capacity. The potting mixture with higher proportion of sand lacks aggregation because of which the container soil get dispersed at the time of planting leaving the seedling naked, planting of which may result in poor survival (Khedkar and Subramaniam, 1997, Srivastava et al., 1998, and Srivastava et al., 2002).

Nitrogen and phosphorus fertilizers are already used to improve tree growth and reduce rotation length (Miller, 1981). Application of Urea and SSP in lowest quantity in soil mixture improves growth and dry weight of *D. sissoo* in nursery. Increased growth and dry weight of seedling in response to nitrogen and phosphorus application has been observed in certain other species (Pope, 1987 and Kout et al.,1995).

The declined growth under high doses of fertilizer might be due to toxic effect of high nutrient concentration. High nutrient availability is also reported to have toxic effects on some others species (Musek, 1978). Extention growth of the seedling is not seen to be effected by the application of SSP fertilizer; this is in confirmity with the observation of Prasad (1998) for *Albizzia procera.*

The seedling growth and dry weight parameter indicated response on the gradient of the soil mixture and fertilizer doses. *D. sissoo* is a pioneer species (Champion and Seth, 1968) and these results are in conformity with the previous observation indicating that early successional species exhibit broader responses on environmental gradient then the late successional species (Parresh and Bajaj 1982, Rao and Singh, 1985 and Ginwal et al., 2002).

The soil environment has great influence on seedling growth beside the nutrient status. A lot of work has been done in this regard earlier as Abod et al. (1979) found air and soil temperature influencing the root generation potential in *Pinus caribaea* seeds

markedly, with soil temperature playing an independent role. Stansky and Wilson (1967) studied the effect of soil moisture and texture on root /shoot weight of transplanted pine seedling and stated that increasing clay content of soils and repeated droughts inhibited shoots and root development. Funk (1971) found better growth of black walnut seedling in conventionally shaped pots containing the 3:1 sand peat mixture. Similarly, Montana et al. (1977) studied white fir seedling growth in relation to saw dust as potting medium and concluded that old sawdust and peat improved the seedling quality while, new sawdust reduced growth substantially. Rawinski et al. (1980) described the soil properties and coniferous seedling growth in North Wisconsin and concluded that soil organic matter, pH, texture and microclimate were related to growth. Minore et al. (1969) concluded that soil density influence the seedling growth in eight pacific north western tree species.

In India, studies have mainly concentrated upon the natural and artificial regeneration potential of some forests, as was evident from the work of Seth and Khan (1958), Nath and Kamath (1967) and Khare (1981). The dieback mechanism which is very common in some economic tree species has also been paid due attention by Troup 1921. Goodman (1959), Champion and Seth (1968), Prasad (1976) and Gupta et al. (1973) studied growth rate of the phytomass both under and above ground part of some *Acacias* in the nursery stage. Gupta (1978) further worked out seedling morphology and phytomass of *B. retusa* over a period of six months and concluded that this species is promising for reforestation of limestone quarry soils and degraded community lands. Further Khare (1981) studied seedling stages in some detail for their structure, performance, growth pattern and mortality under natural conditions and concluded that both edaphic and microclimatic factors govern the growth of seedling. Khare (1981) studied ecological effects of fire in dry deciduous forests and opined that repeated incidences of fire should be controlled in these forests.

In India, gibberllic acid has been successfully used to induce extension growth in some forest species (Nanda and Purohit 1964). In looking back over the many heterogeneous effects of hormones on growth and the development of plants, it is evident that the variety and the range of response elicited by these substances are unique. In much of the work with hormones great diversity in type of response has been observed. The response obtained frequently depend on many factors such as the kind or variety of plants used, the part of the plants treated and its stage of development, the amount of hormone observed and the kind of harmone applied. Gibberellic acid is known to influence a

number of physiological processes in plants in our country. This growth hormone has been tried against several agricultural and horticultural crops and their response is studied in many plant species.

Paul (1956) Stowe (1957), Chakravarti (1958), Nanda (1967) and Abu zied (1973) reported that the GA treatment tend to increase the stem height and decrease the umbel number. Mehrotra and Dadwal (1978) have suggested that the application of GA at 100 ppm followed by weekly application of urea on *Tectona grandis* seedlings is more effective as it increases the overall growth of the plant. The effect of IAA has been reported by Chaturvedi (1998), Baines (1980) and Mehrotra (1982) has described the effect of growth regulators on wheat. Similar effects of IAA were described by Rajput (1992), Tiwari (1994) and Jain (1996) has studied the effect of growth regulators on seed germination on pigeon pea and *Cajanus cajan.*

Singh et al. (2000) have studied response of aged bamboo (*Dendrocalamus hamiltonii* L) seeds to application of GA and IBA. Gayatri et al. (2005) has tested seeds of some forest tree species for germination and seed borne fungi. Mohariya and Patil (2003) have studied response of different varieties of *Chrysanthemum* to growth regulators and observed different effect of different growth regulators.

Similar beneficial effects of exogenous application of GA_3 on seed germination were recorded in *Picea smithiana* (Chandra and Chauhan, 1976), *Pinus caraibaea* and *Pinus patula* (Bhatnagar, 1980), *Pinus kesiya* (Verma and Tondon, 1984), *Quercus leucotricophora* (Singh et al. 1995), Gautam and Bhardwaj (2001), *Pinus wallichiana* (Gera et.al. 2003), *Picea smithiana* (Labania and Singh, 2005). Kiran et al. (2001) studied the seed germination of *Givotia rotteriformis*, a forest tree on the verge of becoming extinct from the forest of Andhra Pradesh. Ghyare (2005) and Lavania et al. also studied the effect of GA_3 on germination of 5 timber tree species.

Chaturvedi (1998) has worked out some selected forest tree species. The effect of growth regulators on seed germination and growth performance of *Bridelia retusa* seed were studied by Chaturvedi and Bajpai (1999). More recently Massodi and Massodi (2000) described the growth behaviour and germination in *Ulmus wallichiana* seeds. The treatment of GA of 1000 ppm in *Acacia* seedlings gave significant height growth, shoot and total dry weight in comparison to all other treatments (Bhatnagar and Singh, 1981). Mishra (1984) reported the application of lower dose GA_3 10 ppm in *T. grandis* and 15 ppm in *D. strictus* induce a promotive effect on growth and dry weight of shoot and root

respectively. The application of difference doses of GA increased shoot growth of seedling but its effect on root growth was retarding. However, different concentration of IAA enhanced root growth in Parthenium (Prasad et al., 1986). Talwar and Bhatnagar (1978) during their study on *Pinus caribaea* seedlings found that the 10 ppm concentration of IAA has given maximum fresh and dry weight and holocellulose production. Sircar (1965) has observed that GA brought about stem extension and number of internodes but decrease leaf expansion basal thickness of stem, lateral bud development and fibre growth particularly at relative higher concentration. Applications of IAA on the other hand result in increased growth of the plant in most respects. Bhosle and Joshi (1970) during the study of *Terminalia cattappa* Linn. observed that IAA was more effective when applied with aspartic acid. Shamshery and Kumar (1982) studied the effect of some growth regulators on *Ablemoschus esculentus.* GA increased seedling growth and fresh and dry matter production probably GA initiates the greater mobility of reserve food from the cotyledons.

Rumenska et al. (1978) have studied on the effect of gibbrelic acid on seed germination of some vegetable and medicinal plants. Roy (1985) has worked on seed germination and polymorphism in *Albizzia lebbek.* Nanda and Purohit (1964) investigated on auxin effects on rooting of stem cutting of forest plants. Maithani and Bahuguna (1996) have studied on sowing of *Azadirachta indica.* Kumar et al. (2007) have given a note on twin seedling on *Pterospermum ocerifolium* and *Dalbergia sissoo.* He has also observed polyembrony in *Acacia farnesalumm.* Kumar and Bhatangar have worked on the effect on temperature and substratum on the germination of *Dalbergia sissoo.*

Kumar and Tokyo (1996) have studied on variation in seed germination and juvenile growth of 12 provenances of *Albizzia lebbek.* Levan and Barton (2000) have studied the effect of gibbrelic acid on growth on Kentucky blue grass. Mishra and Jaiswal (2000) have studied the effect of plant bio-regulators and potassium nitrate on seedling quality of Bael (*Aegle mermelos*) and also suggested provenance variation in *Casuarina* species with reference to germination and growth.

Rana and Rao (1997) have done germination studies on few multipurpose nitrogen fixing tree species use in afforestation programme in central Himalayas and Karnataka. Paddy et al. (1997) have worked on rapid invitro germination of Teak (*Tectona grandis*). Banergi (1998) has observed germination of *Melia* seeds with IAA, IBA and GA_3. Pandey and Khatron (1999) have investigated on the orientation of seed

placement and the depth of sowing on seedling emergence in *Sterculia urens*. Nizam and Hussain (1999) have studied effect of seed weight of germination and initial seeding growth in *Albizza saman*. Saha (1999) have observed the effect of storage on seed viability in some leguminous taxa.

Nanda et al. (1970) has studied the effect of growth regulators on stem cuttings of herbaceous and forest tree species. Sharma (1970) worked out physiognomy, behavior in nursery, and response to artificial method of reproduction of some Andaman timber species. Shrivastava (1972) studied the competitive potential of Sal seedling and concluded that different competing species influence growth and nutrient uptake of other species.

MORPHOLOGY

Botanical Name: ***Albizzia lebbeck*** **(L) Benth**

Family: Leguminosae (Mimosoideae)

Common Name: Sarshio, kalshish, siris, koroi, kalsis, sharin, shrirish, vakai,

Distribution: *Albizzia* is one of the common trees of India. It is extensively planted in agroforestry system. It is native also to Bangladesh, Burma and Pakistan and has been cultivated in tropical and subtropical region in North Africa, West Indies, South America, and Southeast Asia (Anon, 1980)

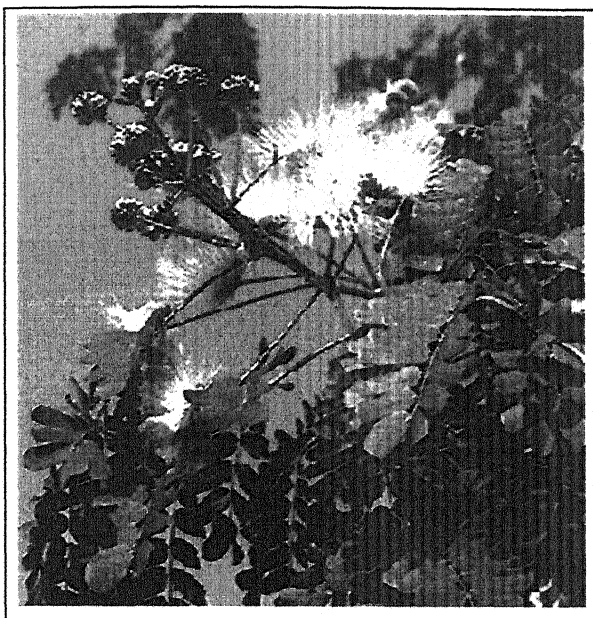
Ecology: The species prefers annual rainfall between 500 to 2500 mm but is capable to withstand short periods of drought. It is frost hardy. In areas where it has been planted in the temperature range varies from 5° C in the winter to 45° C in the summer. The tree grows on a variety of soil, e.g. drained loam, clayey soil, laterite or black cotton soil. It can grow on poor soils (mild alkaline and saline soils).

Botany: *Albizzia lebbeck* is a tropical hard wood species. It is a moderate to large deciduous tree. Flowers greenish-white, shortly pedicellated; calyx funnel shaped, short-toothed; corolla twice the length of the calyx. Pod flat, thin, straw coloured, 5-10 seeds, with brown spot (Singh and Srivastava, 1989). The tree bears plenty of foliage readily eaten by cattle sheep and goats.

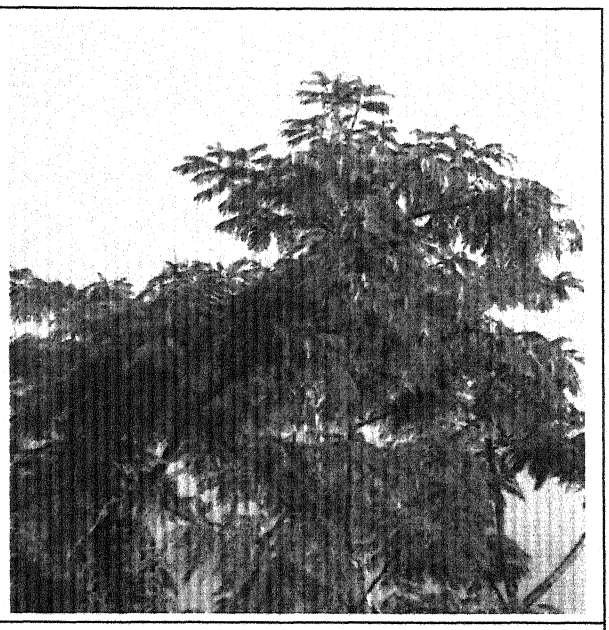
Establishment: *Albizzia lebbeck* produces seed prolifically. Generally seeds are immersed in boiling water and allowed to cool and soak for 36 hours. The chemical scarification consisted of immersing the seeds for 5 minutes in concentrated sulphuric acid, washing the seeds with water; and the mechanical scarification involves soaking the seed in water brought to boiling point for 24 hours. The tree can be raised by the direct sowing. Direct sowing of seeds in lines can be done in June or before monsoon showers. Stem cuttings or root-shoot cuttings are also satisfactory. Planting has definite advantages over direct sowing.

Utility: The wood *of Albizzia lebbeck* burns well. *Albizzia* is a strong wood, being about the same weight and hardness as teak. The wood is excellent for high class furniture, interior decoration, and panelling (Trotter, 1982). Its fodder is a valuable supplement to pasture in North Bihar. *Albizzia* forage has about 20 per cent protein. The foliage may be

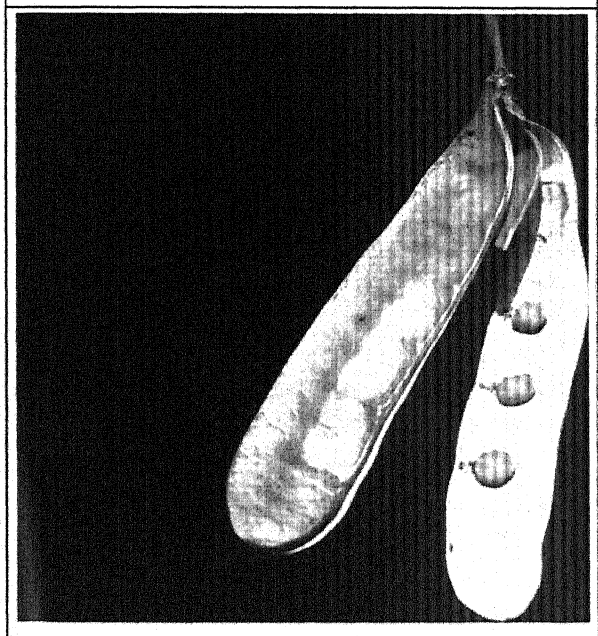
Plate - 1



A FLOWERING TWIG



A COMPLETE TREE



A POD SHOWING SEEDS

BUNCH OF PODS

ALBIZZIA LEBBECK

used as green manure or mulches in agroforestry system. *Albizia lebbeck* is good soil binder.

Botanical name : *Albizzia procera* (Roxb.) Benth.

Family : Leguminosae (Mimosoideae)

Common Name: Modeloa, medeloa, safed siris, bagai, konda, vagai sirsi, chikul.

Distribution: *Albizia procera* is one of the important multipurpose trees of India. It is found all over Assam, Bihar, Northern Madhya Pradesh, Andhra Pradesh and Central and Eastern Uttar Pradesh.

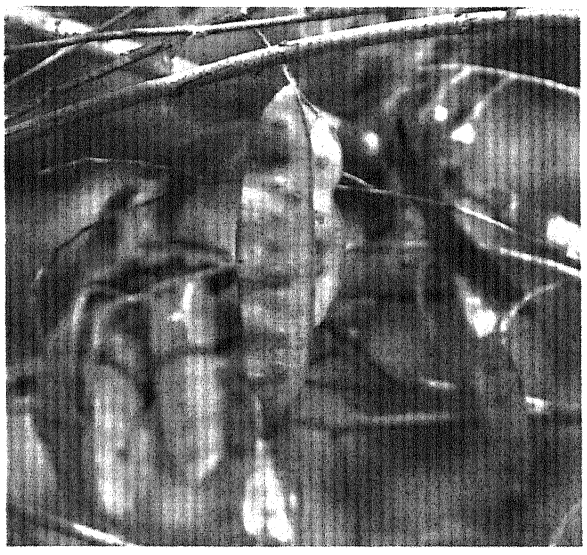
Ecology: In its habitat, the maximum shade temperature varies from 37° C to 46° C and the absolute minimum from 10^0 C to 18° C Annual rainfall varies from 1000 to 4000 mm. The trees cannot tolerate frost. It is found growing on a variety of soils *e.g.,* alluvial soil, clayey and moderately alkaline and saline soils, red sandy and loamy soils. If soil moisture level is low, attains smaller size.

Botany: *Albizia procera* is large graceful tree with a oval crown bark yellowish or greenish-white, smooth, peeling off in thin flakes, often with horizontal lines. Pods 10-20 cm by 1.8-2.5 cm glabrous, brown, 8-12 seeded with darker blotches over the seeds. The flowering commences from the first week of August and lasts for about two weeks. Ripe fruits begin to appear on the trees from the beginning of April. By the end of this month, the pods are ripened. By the third week of May all the pods, ripen and begin to disperse the seed (Krishnaswamy and Muthauda, 1954).

Establishment: Treatment of seed is required before sowing in the nursery bed. Chaudhri (1957) reported soaking of seeds in water for 12 hours before sowing. The seeds are sown in the beds at 7.6 x 7.6 cm in the month of May. Watering is essential and care is taken to see that beds remain wet thoroughly atleast twice a week. Germination continued for 3 weeks or more.

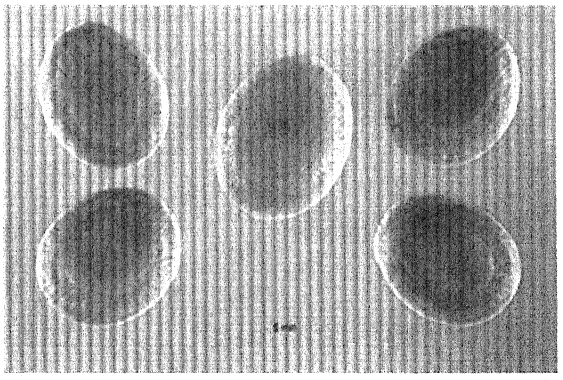
Utility: Branches of trees are utilised as fuelwood. Its charcoal is considered very good. The hardwood takes a fairly good polish, seasons well and is very durable (Khanjilal, 1929). The *Albizzia procera* wood is excellent for high class furniture. The bark is used for tanning. Like *Albizzia lebbeck,* its fodder is valuable supplement to pasture, sheep and goat. The foliage is good green manure. This tree is one of the important nitrogen fixing tree species.

FLOWERING TWIG



PODS

A TWIG SHOWING PODS



SEEDS

ALBIZZIA PROCERA

Botanical name: *Azadirachta indica* **A. Juss.**

Family: Meliaceae

Common Name: Neem, nimgachh, nimb, bevina, kiri-bevu, veppu, vepa, yepa, veppam, vempu, khumba, balnimb, bevu.

Distribution: The tree is native of India, Indonesia, Sri Lanka, Burma, Pakistan and Thailand. It is common in Bihar, West Bengal, Orissa, Gujarat, Maharashtra, Karnataka, Tamil Nadu and Assam.

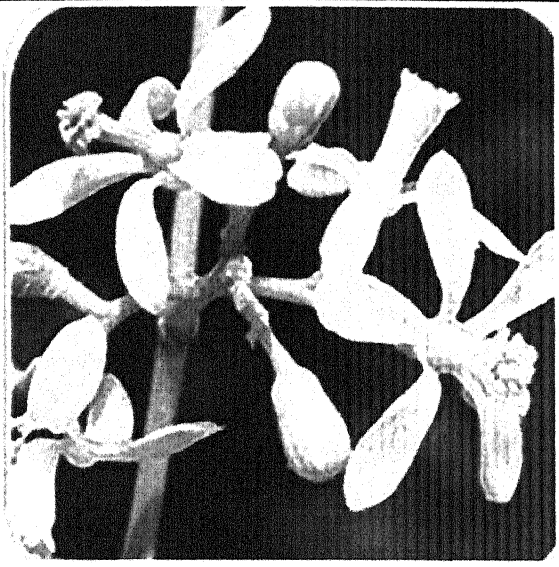
Ecology: In its natural habitat, the absolute maximum shade temperature varies from 30°C to 48^0 C and the absolute minimum from 10^0 C to 16° C. It grows satisfactorily on sites that receive rainfall from 450-1200 mm or more. It is found growing under a wide range of soils. It is planted in black cotton soils, alkaline soils, dry stony shallow soil, and well-drained loams. On silty sands and in clayey depressions it remains stunted.

Botany: A very handsome evergreen tree with wide spreading branches and forms rounded dense crown. The height of neem is commonly 10-25 meters. The panicle of white flowers appears during March to May and fruits ripen from June to August. Normally fruits collected from the ground are sown immediately, the seeds have short viability period of 8 to 10 days (Randhawa, 1983 and Nagveni et al., 1987).

Establishment: Seeds should be collected in the month of July and August. The greenish yellow fruits collected from the trees are depulped. The seeds are dried under shade to bring down the moisture level to around 5 per cent (which is normally obtained by keeping the seeds under shade for 2 days). These are damaged early, when they are in the moist condition, especially when they are covered or enclosed with mucilaginous fleshy mesocarp, when the seeds are enclosed in 'the mucilage for 3 to 4 days. Seeds are sown in July to August. Shading is not required in the nursery. The seedlings are watered throughout the hot weather. It docs not withstand winter planting.

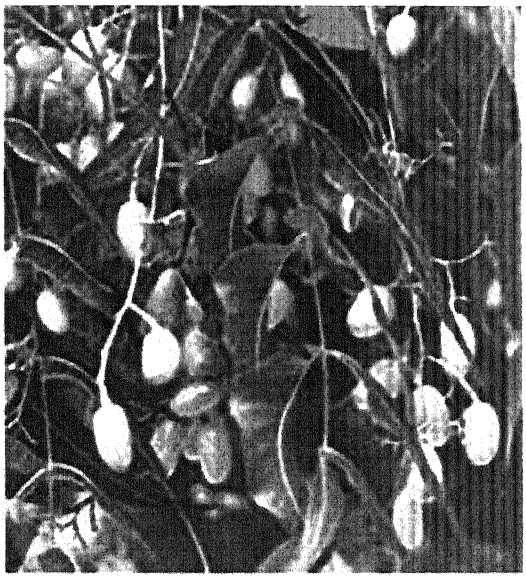
Utility: It is an easy wood to saw and work to a good finish. It is very popular wherever it is found and is favourable wood for panels, furnitures, boat buildings, toys, agricultural implements, etc. The branches are used as firewoods. Neem tree has been used successfully in Rajasthan as shelterbelt. Neem is a tree ideally suited for agroforestry system and wasteland plantation. Its leaves and twigs are used as mulch and green manures. Neem foliage is a valuable supplement to grass and an excellent fodder for

Plate - 3

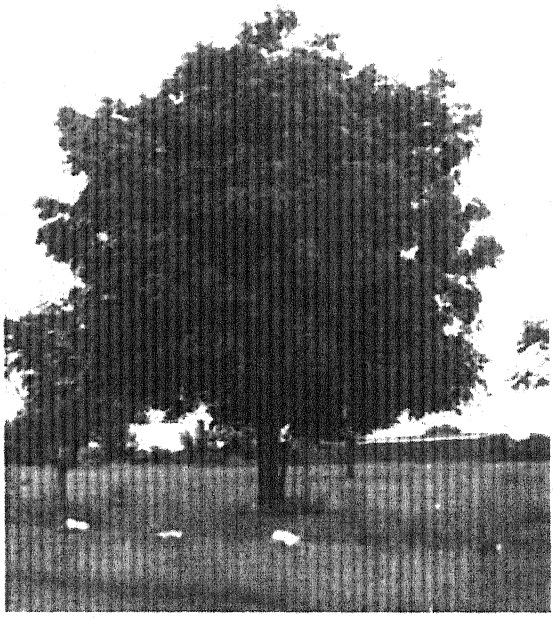


FLOWER

PODS



A TWIG SHOWING PODS



A COMPLETE TREE

AZADIRACHTA INDICA

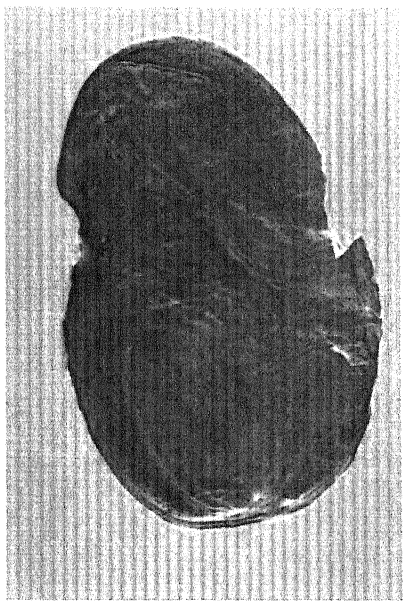
goats. The seeds of this plant contain oil (margosa oil), which is in great demand for pharmaceutical, soap and disinfectant industry. The seed cakes can be processed to produce biofertilizer, thus biofertilizer industry in conjunction with oil extraction can also developed (Tiwari, 1983).

Botanical name: ***Butea monosperma*** **Roxb. (Lam.) Taubert.**
Family: Leguminosae (Papilionaceae).
Common name: Dhak, palash.

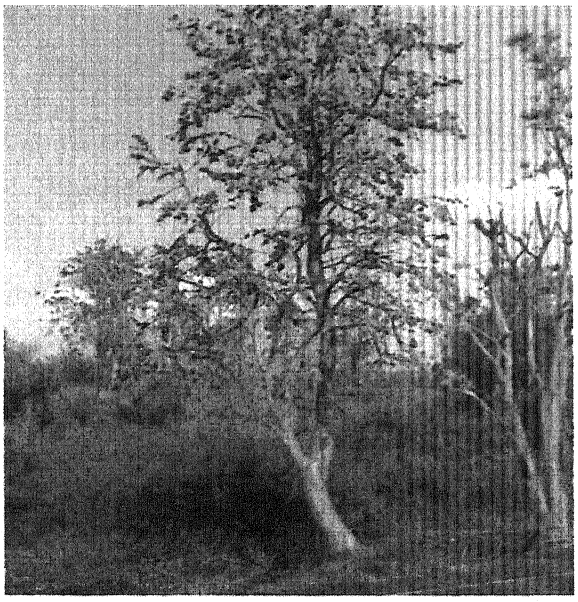
Distribution: Found throughout the drier parts of India, often gregarious in forests, grasslands and wastelands. It is characterstic tree in the plains, often forming pure patches in grazing grounds and other open places.
Ecology: It grows on wide variety of soils including shallow gravelly sites, black cottony soils, and clay loams and even on saline soils or in waterlogged situations.
Botany: *Butea monosperma* is a small to medium sized (5-15 m tall, up to 43 cm dbh) deciduous tree, open-crowned, untidy in growth and rugged in shape with a twisted and gnarled trunk. . The fruits are pods 10-20 by 2-6 cm, flat, woody and tomentose, covered with silvery white hair, dehiscent, and containing one seed at the end (Brandis, 1921). Seed are obovate, compressed and brownish. The best season for collection of seeds is during May-June.
Establishment: Natural regeneration, both by seed and by root suckers, is profuse. Seeds germinate early in the rainy season not long after the fall of the pods. The seedlings are *avoided* by cattle and goats. Artificial Propagation is chiefly from direct-sown seeds, the distance between seeds should be 25-30 cm which are sown in parallel lines 3-5 m apart ,often using "taungya" since weeding during the first year or two is essential to the proper development of the plants. As with **natural regeneration**, young plants suffer greatly from animals and in such places it is almost hopeless to attempt raising plantations of *Butea* unless some means of preventing their depredations can be applied.
Utility: Leaves of *Butea monosperma* are widely used as dining plates in many places of rural India. Leaves are sometimes used as fuel and are burnt in the absence of oxygen. Young leaves are classed as good fodder eaten mainly by buffaloes. It quickly produces a fresh flush of leaves after the young leaves are harvested. The tree makes a good host for lac cultivation, for which it is managed by pollarding. *Butea*, in open well construction it

Plate - 4

FLOWER



SEED



FULL LENGTH TREE

FULL LENGTH TREE

BUTEA MONOSPERMA

is used as a base (foundation) material over the stone wall lining is built. Also used in making wooden pulley and well curbs.

Botanical Name: ***Dalbergia sissoo*** **Roxb.**

Family: Leguminosae (Papilionaceae)

Common names: Sissu, tanach, shisham, simsapa, shisha, aguru, sissu-karra, erresissu.

Distribution: The tree is widely distributed. It is found in sub-Himalayan tract and also in the Himalayan valleys, usually upto 1500 m. It has been planted in many parts of Andhra Pradesh, Bihar, Uttar Pradesh, Gujarat, Maharashtra, Tamil Nadu and Haryana.

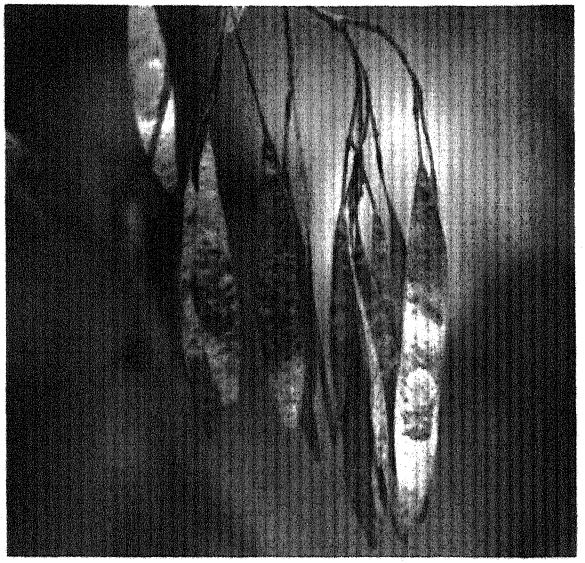
Ecology: This species prefers an annual rainfall between 760 to 2500 mm but able to withstand short period drought. In areas where it has been planted, the absolute maximum shade temperature varies, from 39° C to 49° C and absolute minimum from 4° C to 6° C. The species is frost hardy even in the sapling stage. It grows on sandy alluvial, porous soil of sand pebbles and boulders. It is also found on freshly exposed soil along roads and streams. It can grow on very poor soils.

Botany: It is a fairly large and, fast growing multipurpose tree species. It attains a height of upto 30 m. Seeds kidney shaped, flat.

Establishment: Sowing is done in the nursery beds which are normally 40 cm wide at the base and 30 cm wide at the top and 25 cm high. The seeds are soaked in water for 48 hours before sowing. Optimum depth of sowing is about 1.5 cm. The beds are irrigated soon after sowing. Regular irrigation is necessary for germination and for good growth of seedlings. This species can be propagated through almost all the common methods. Multiplication by vegetative means offers the advantage of greater genetic uniformity and immature availability of superior clones for plantation in agroforestry programmes.

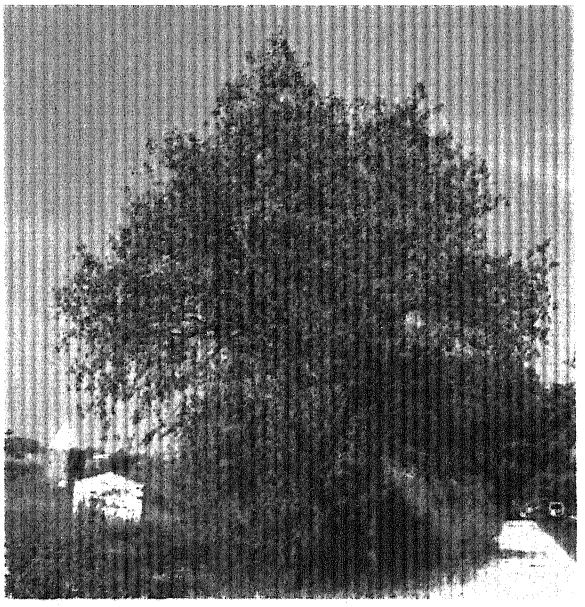
Utility: The branches are used as fuelwood. Sissoo is a good valuable fire wood. The wood is extensively used in furniture industry, musical instruments, farm implements, cart carriage and wheel works industry of rural areas and also for carving by artisans (Tiwari, 1985). During scarcity period the leaves may also be used as fodder. The chopped leaves when used as green manure improves fertility status of soil. The bark is used to check Cholera.

A TWIG WITH SEEDS & FLOWER



PODS

A TWIG WITH BUDS AND FLOWERS



A COMPLETE TREE

DALBERGIA SISSOO

Botanical Name: ***Holoptelia integrifolia*** **Planch.**

Family: Ulmaceae

CommonName: Chiraul

Distribution: It is planted in and around open cultivated lands and near villages.

Ecology: Its natural occurrence in India is scattered in dry deciduous forests from the Sub-Himalayan foothills to 700 m altitude down to the plains of peninsular India. It is mainly a species of the tropical and subtropical zone with maximum temperature to 47° C and rare frosts; in the rainfall zone of 500-2000 mm Troup, 1921 and Singh, 1982).

Botany: *H. integrifolia* in the mature forest is a large (up to 30 m tall, 1.4 m dbh) deciduous tree with strong ascending and spreading branches. On poor or dry sites it is smaller, and with repeated lopping and browsing it can be reduced to a productive multistemmed shrub. Flowers small, greenish, in short lateral compound corymbs appear in February while the tree is leafless. Male and bisexual flowers are mixed. The fruit has membranous wings (a samara), nearly orbicular, about 3 cm in diameter, on a slender stalk ripens in April-May (Singh, 1982).

Establishment: Natural regeneration occurs by seeds, which germinate after the start of rains. The winged seeds disperse quite long distances due to air current during seed maturation time. Few survive, however, except in years with good rainfall distribution to carry them through the hot summer .On prepared soils under or near mature trees, a good crop of seedlings can be obtained without difficulty. Artificial propagation is best by direct sowing, but can also be done with transplanting of wild seedlings or by planting nursery-raised seedlings.

Utility: The trees are lopped for fodder regularly (Singh, 1982).The light yellowish grey wood is moderately hard and is little used. The trees yield oil (Troup, 1921).

Botanical name: ***Leucaena leucocephala***

Family: Leguminosae (Mimosaceae)

Common name: Su- babul

Distribution: *Leucaena leucocephala* is a native of Central America and has been introduced widely in many tropical countries. Earliest trials in India date back to 1976

Plate - 6

TWIG

A TWIG SHOWING PODS

A COMPLETE TREE

HOLOPTELIA INTEGRIFOLIA

(Chaturvedi, 1981 and Singh, 1982) and it is now found throughout the moist and semi-arid areas of India, extending up to an altitude of 1200 m.

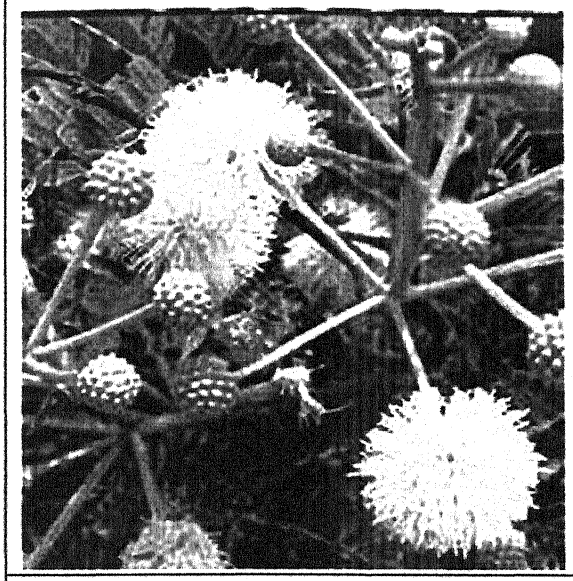
Ecology: *Leucaena* can grow on a wide range of soil types; grows best on deep, well-drained, loamy, neutral or slightly alkaline soils but has major problems with acid or saline soils, low phosphorous, low calcium, high aluminium salts and water logging. It can tolerate high temperatures up to 48° C; it is frost-sensitive and dies back, but re-grows from ground level if the frost is not too severe (Parkash and Hocking,1985). The annual rainfall in its zone of best performance is 600-2000 mm (Parkash and Hocking 1985).

Botany: Pods grow in large bunches, straight, flat, long (12-20 x 2-2.5 cm), each containing 15-30 seeds. Immature pods are light green to translucent, mature pods brown, shining, with waxy coat; open spontaneously when dry, Seeds dark brown; testa hard and shining, (Anon, 1977; Anon 1980 and Singh, 1982).

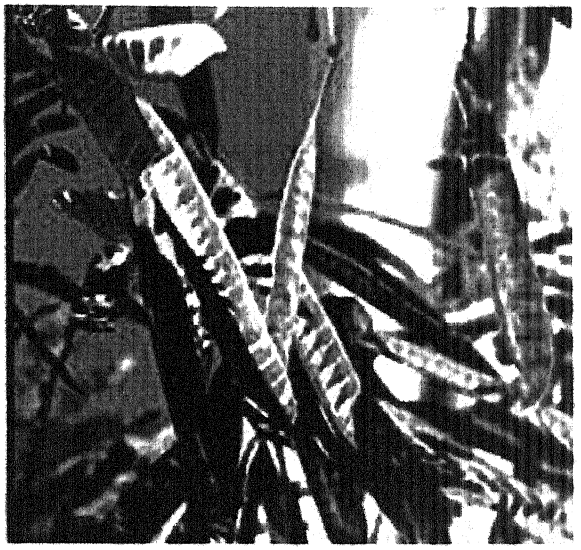
Establishment: *Leucaena* reproduces itself freely through seed and coppice, It seeds profusely from an early age (particularly the Hawaiian type) and seeds are dispersed after splitting of ripe pods. Conditions necessary for favourable germination are sufficient light and moisture, and freedom from tall weeds, dense shade and browsing damage (Singh 1982). In artificial propagation *Leucaena* can be raised by direct sowing, or by planting container-raised seedlings, ripe pods are collected before they open, and spread to dry and then stirred to separate seed.

Utility: Leaves, pods and seeds are nutritious, palatable and digestible forage containing 20% crude protein (Anon 1977, Anon 1980); relished by cattle, sheep and goats. However, some varieties contain an alkaloid, mimosine, in their leaves, which is toxic to ruminants that lack mimosine-destroying rumen microorganisms. Fresh milk from *Leucaena*-fed cows is yellow and has an objectionable odour which, however, disappears on boiling; L*eucaena* leaves should not be fed within two hours of milking.

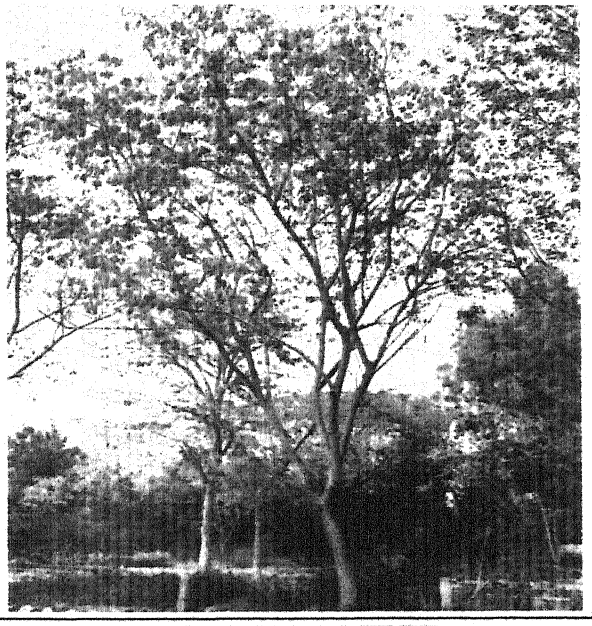
It is hard, heavy (about 880 kg/m^3), and easily workable for a wide variety of carpentry purposes; makes cheap construction timber; poles are used as fence posts (Parkash and Hocking 1985 and Anon, 1980). It makes good firewood and charcoal but is inferior to that of *A. nilotica* and *P. cineraria.* It has the potential of becoming a major source of short-fibred pulp for paper manufacture, in conjunction with long-fibred (e.g. bamboo) pulp (Anon, 1980).



A TWIG WITH FLOWERS



PODS



A COMPLETE TREE

LEUCAENA LEUCOCEPHALA

Botanical Name: ***Tamarindus indica*** **L.**

Family: Leguminosae, Caesalpinoideae

Common Name: Imli

Distribution: *Tamarindus indica* originated in Madagascar (Von Maydell, 1986) and is now planted throughout semi-arid tropical Africa and South Asia, where it has naturalised in some places. *Tamarindus indica* can grow on soils ranging from gravelly to deep alluvial; thrives best in deep loam, which provides optimum conditions for development of its long tap root. It tolerates slightly alkaline or saline soil (Anon, 1983).

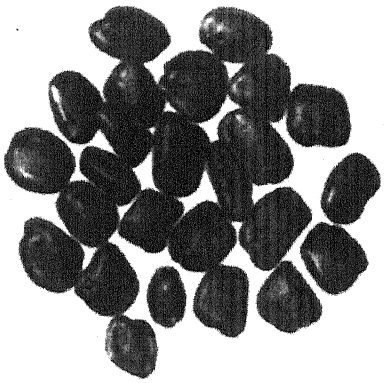
Ecology: *Tamarindus indica* is essentially a tree of tropical climate, tolerating temperatures up to 47° C but is very sensitive to frost and fire (Parkash and Hocking, 1985). Prefers mean annual rainfall of 500 to 1500 mm (Singh, 1982) and tolerates water logging, but also grows well with only 350 mm annual rainfall if watered for establishment.

Botany: The *Tamarindus indica* is a large (height 30 m, dbh 1.6 m), handsome, long-lived, evergreen tree with spreading crown up to 12 m in diameter, widely cultivated for shade and fruit. In hot and dry localities, it is briefly leafless (Chaturvedi, 1956). . Seedlings and saplings are instantly recognizable by characteristically drooping leading shoot. Pods 7-20 x 2.5 mm, brown, slightly curved, indehiscent; 1-8 seeded. Seeds 3-10 x 1.3 cm, irregularly shaped; testa hard, shining, smooth; embedded in reddish-brown acid pulp (Anon, 1988).

Establishment: Natural reproduction occurs from self-seeding when protected. Monkeys eat the fruits and scatter the seeds; germinants survive under protection of bushes (Anon, 1983). It coppices fairly well and produces root suckers.

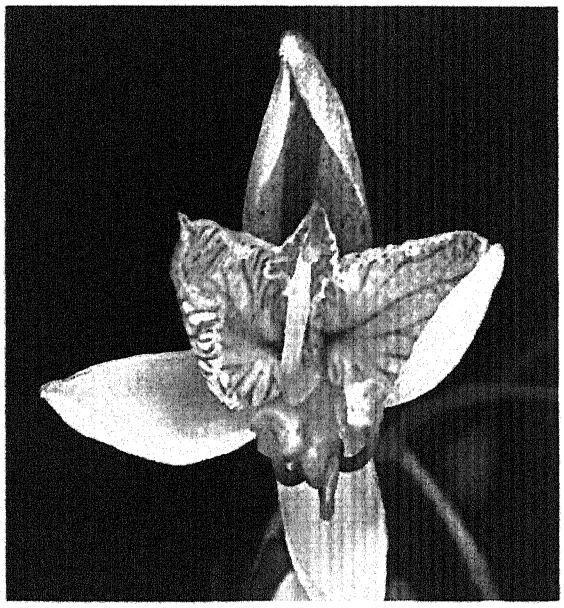
Artificial propagation is by direct sowing, seedlings, stump planting, and vegetatively by branch cuttings and layering for superior trees (Singh, 1982). For seeds, ripe pods are collected from the trees in March-April by shaking the branches, and are dried in the sun.

Utility: *Tamarindus indica* is valued mainly for its fruit; its acidic pulp is a favourite ingredient of culinary preparations like curries, chutni, and sherbet. Seeds are extensively used in jam, jelly and confectionary industries and making condiments (Parkash and Hocking, 1985). Leaves are used to poultice wounds; they also yield a red dye. Seeds are used in treatment of dysentery and constipation. Bark is a tonic and an astringent. Its seeds (kernel powder) are used in textile and jute industries for sizing, and as filler for

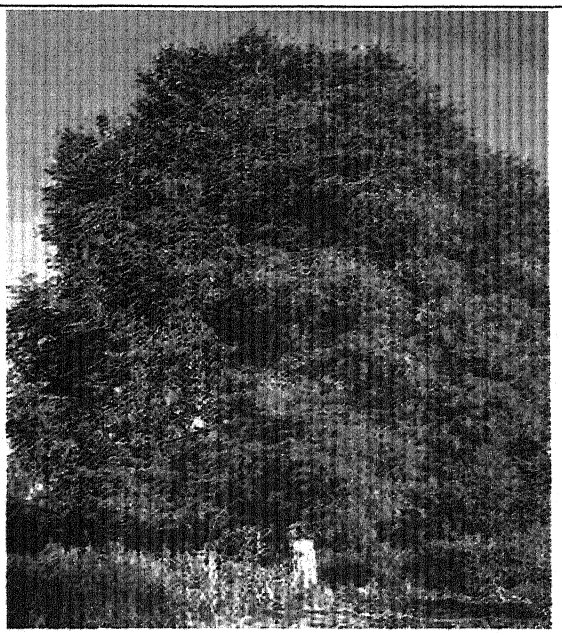


SEEDS

A TWIG SHOWING PODS



FLOWER



A COMPLETE TREE

TAMARINDUS INDICA

adhesives in plywood industries. Its seed testa is used for tanning leather; Seeds give amber coloured oil, made into a varnish to paint idols (Anon, 1983).

SELECTION OF APPROPRIATE FOREST TREE SPECIES

The understanding of selection of appropriate forest tree species on the scientific basis is of great silvicultural importance. The assessment of favourable environmental conditions for their development and growth may lead to their higher production and survival. The latter are important for afforestation and reforestation practices .Tree form is determined mainly by heredity and age but successional trends in different areas should be understood from the point of view of the seedling, as it is the establishment of young plants that determines to great extent, if not wholly, the occurrence of existing forests (Giri Rao et al., 2000).

It is a common view now to protect the environment one has to depend for more and more afforestation and reforestation programmes, the understanding of appropriate forest tree species, their better quality of seeds and their better germination is the pre requisite of these programmes (Nandeshwar, 2006). Keeping this view in mind the present study was planned to have a scientific understanding of seed ecology of some tropical forest tree species (Hooda et al., 1993, Tang, 1996 and Thakur et al., 2000).

It is a well known fact that environment and plant are closely interrelated and have great bearing on seed and its germination, growth and development of plant etc, so it becomes inevitable to understand the ecological factors which are wholly responsible for growth and further development of plant. It is an essential basis for formation of most desirable means of determining the plant producing value of seed (Sen, 1977).

The following species were selected to study the growth of seedling: *Albizzia lebbek, Albizia procera, Azadirachta indica, Butea monosperma, Dalbergia sissoo, Holoptelia integrifolia, Leucaena leucocephala* and *Tamarindus indica* .These species were selected because these were either dominant or codominants in dry deciduous forests of the study area, and are commonly used for afforestation and reforestation practices. Moreover, these are easily available. Some more causes for selection of there species are as follows:

Almost all the above mentioned species are highly versatile, fast growing and well suited to management in agroforesty systems, they are commonest and are widely distributed in world wide tropics. Bhimaya and kaul (1966) studied the growth of root system of *Albizzia lebbeck* grown in a cylindrical container 78 cm high and 50 cm diameter, till the end of first growing season and found that in a period of 153 days, the length of the tap root grew to 43 cm and the number of lateral roots was 40. The length of shoot portion during this season

was 25 cm in *Albizzia lebbeck. A. procera* has been successfully used for plantation in farm/agroforestry system.These species have been successfully introduced in saline areas. *Dalbergia* and *Holoptelia* are fast growing and fairly large multipurpose tree species and attain height up to 30 m. On poor or dry sites, *Holoptelia* is smaller, and with repeated looping and browsing it can be reduced to a productive multistemmed shrub.

Of these, *Leuceana leucocephala* is highly versatile, fast growing, nitrogen fixing tree well suited to management in agro forestry systems, highly productive of palatable nutritious fodder and with a choice of management of fuelwood and timber. The fast growth, wide variety of uses and nitrogen fixing capability of Rhizobium inoculated *Leucaena,* makes it one of the most useful agro forestry species within its range. As a perennial species in alley cropping it serves for soil conservation and wind break .The farmer may take the loppings for fodder and add these to the soil as mulch. As compared to all the species the rate of growth of species like *Azadirachla indica, Butea monosperma* and *Tamarindus indica* is moderate to slow but these species are raised because of their high economic value.

Tamarind tree is much loved throughout the semi arid regions for its deep, cool shade and for is valuable pungent fruits. Less well known are its excellent leaf fodder and high quality timber. Inspite of slow growth of *Azadirachta indica*, it is ideally stated for agro forestry system and wasteland plantation as its leaves and twigs are used as mulch and green manure. It brings slow but steady improvement of the site, making it fit for moderate quality pasturage and poor wood production (Anon, 1983).

Butea is frequently used inspite of its slow growth because of its showy, flame coloured flowers, drought hardiness and frost resistant capacity. It is useful source of fuel and leaves in coppice management at wide spacing on heavily grazed grassland. It generates cash income from production of lac by insects living on the shoots.

All the selected forest species can grow on soils ranging from drained loam, clayey, laterite or sandy alluvial porous soil of sand, pebbles and boulders. They are also found on fleshly exposed soil along roads and streams or even on saline soils or in water logged situations. On the contrary, on silty sands and in clayey depressions *Azadirachta*'s growth remains stunted. *Leucaena* has major problems with acid or saline soils, low phosphorous, low, calcium, high aluminum salts and water logging.

All the species which are selected for afforestation programmes can withstand adverse environmental conditions. They can tolerate excessive drought and can withstand

water logging, Rainfall requirements are modest They can survive in areas with as little as 450 mm annual rainfall or as much or 4500 mm.

Butea monosperma is slow growing but is very drought resistant and frost hardy, although the leaves turn white and fall off growing in temperature range of 4^0 to 49^0c in localities subjected to severe frost or drought. Shoots remain small and often die back due to frost or drought, new shoots being sent by subsequently .The dying back may continue for two to three subsequent years or more until the plants become sufficiently established to send up permanent shoots.

Leucaena laucocephala and *Tamarind* are essentially trees of tropical climate, tolerating temperatures up to 48^0 but are very sensitive to frost and (Parkash and Hocking, 1985) prefers mean annual rainfall of 500 to 2000 mm and tolerate water logging, but also grow well with only 350 mm annual rainfall if watered for establishment. Leaflet folding and leaf drop helps in avoiding excessive drought.

Azadirachta indica can also tolerate excessive drought but does not withstand water logging and its seedling and sapling stage are frost tender in its natural habitat. The absolute shade temperature varies from 30^0 C to 48^0 C and the absolute minimum from 0^0 C to 16^0 C and grows satisfactorily on the sites that receive rainfall from 450 to 1200 mm or more.

Albizzia lebbek, Albizzia procera Dalbergia sissoo and *Holoptelia integrifolia* prefer annual rainfall between 500 to 2500 mm and temperature ranges from 5^0 C in the winter to 45^0 C in the summer and are capable to withstand short periods of drought. *Dalbergia sissoo* is frost hardy even in the seedling and sapling stage.

Bonner (1984) defined seed viability as the state of being capable of germination and subsequent growth and development of the seedlings. Thus it can be said that a viable seed is one which is capable of germination under proper conditions.

Kaul (1965) has experimented on chemical and mechanical scarification of *Albizzia* seeds for breaking their dormancy for detecting viability , The chemical scarification consisted of immersing the seeds for 5 minutes in concentrated Sulphuric acid, washing the seeds with water and the mechanical scarification involves soaking the seeds water brought to boiling point for 24 hours, He has observed that with chemical scarification, the germination is 75 percent which enhanced to 85 percent in mechanical Scarification. Thus soaking in water brought to boiling for 24 hours is an effective for pretreatment of seeds. In case of *Albizzia procera,* soaking is continued for 12 hours (Chaudhri, 1957).

For *Azadirachta indica*, Nagaveni (1987) reported that normally fruits collected from the ground are sown immediately as they have short viability period of 5 to 10 days. This has been a limiting factor in vigourous expansion .The viability of seeds can be improved and extended by adopting the following techniques .The greenish yellow fruits collected from the trees are depulped. The seeds are then dried under shade to bring down the moisture level to around 5 percent. These seeds give germination up to 50 percent for 4 months and the germination gradually decreased to 50 percent in about 6-7 months period. However, germination and viability after 7 months were very low. In case of *Butea monosperma, Dalbergia sissoo* and *Holoptelia integrifolia* seeds or pods should be sown soon after collection as they loose viability within 5-6 months. The germination percent in these species is 60:65% and germination commences in about 2 weeks. Germination capacity of seeds of *Leucaena leucocephala* is 70-85% seed coat being hard, it require pretreatment with boiling water for quick and uniform germination (Chaturvedi, 1981).

Ripe pods are collected before they open and spread to dry and then stirred to separate seed. Properly dried and treated seed of *Leuceana* can be stored for about 8:10 years. The ripe pods of *Tamarind* are collected from the tree in March –April by shaking the branches and are dried in Sun. The outer shell is removed by hand by beating with a mallet, and seeds are sepeated from the edible pulp by hand kneading and washing in water. Washed seeds are dried in shade and stored in gunny bags in dry cool place; it retains viability for about 6months and germinative capacity is 60:75 % (Anon, 1983 and Mastekar, 1977). No pretreatment of seed is necessary (Anon, 1983).

It is evident from the above discussion that the seeds/fruits of all the selected species should be collected before they open and spread to dry and then stirred to separate seed. Properly dried and treated seed can be stored and used for comparatively longer periods. Germination capacity of almost all the selected species is satisfactory which ranges from 70 to 85%. These species were selected from the forests on the basis of their dominance or co dominance in the local forest areas used for afforestation and reforestation practices and their seeds are easily available.

It is apparant from the foregoing account that the understanding of culturing seedling in nursery and the exploration of favourable environmental conditions is more widely studied in European and North American countries rather than in south East Asia especially in India. Their researches have significantly facilitated the practices of afforestation and reforestation because the temperate forests are generally monocultures or

less diverse and the climatic conditions are also favourable for the exhaustive field experiments. Moreover the coniferous temperate forests rarely reach a climatic climax. Therefore a new species can easily be introduced and the older one may be conveniently replaced or regenerated artificially. On the contrary, there was less emphasis on producing good quality seedling in nursery in India and the interaction of environmental and nutritional factor and the dynamics of seedling growth are not properly understood. Moreover, the forests in India are more diverse and static so as to make them regenerated or replaced by other species at convenience. However, the nursery conditions for better quality production of seedlings ought to be explored in greater details so there may be no scarcity of seedlings of existing species for afforestation and reforestation programmes. It become much imperative looking into the fact that the seeds and seedlings consume quite a longer time in field for their germination and establishment than in nurseries where the favorable conditions can be stimulated .

The present work is proposed to fill these lacunae to some extent by exploring the growth and establishment behavior of some common economic tree species and by studying the interactions and interrelationship between the growth of seedlings and their environment.

The success of afforestation and reforestation programme depends appreciably upon the clear understanding of species and their environment and the better understanding of structure and function of forest ecosystem within existing ones from the local regions may lead to identification of fast growing species.

The period of fruit maturation vary to some extent with variation in environmental conditions. The planting value of seed and its storability is directly related to the level of maturation of seeds at the time of collection, extraction and processing of seeds in large quantities in the field. It will be economical and practicable if exact stage and time of collection of seeds of different species are known. Method of seed collection and extraction of seeds from the the fruit also depends upon the nature of the species. Proper care during collection and processing of seeds is necessary for maintaining the healthy lot free from injurious agencies.

Method of collection: On the basis of method of collection these seeds are classified as follows:

Type 1: Immature seeds: The seeds collected from branches of tree directly by hand plucking.

Type 2: Mature seeds: Those which are collected over bed sheet, by causing slight hand jerk to the branches. The seeds fell down due to formation of abscission layer to the base of the stalk are supposed to be mature ones.

Type 3: Mixed seeds: The seeds collected from ground floor, underneath the tree. These include a mixture of immature, dead, infected or decayed and infected seeds. The germination percentage of these seeds is very poor.

Method of collection and extraction of seed from the fruit depends upon the nature of the species.

The majority of the species have a seedling season, which is very short say few weeks only. It is during this short period the maximum amount of seed is to be collected without allowing the dehiscence processs or when they fall down on the ground. Seed should always be collected from selected plant species only. The main objects of seed collection are –

(i): To meet continuous short and long term supply of reproductive material for plantation programmes.

(ii): To ensure the supply of reproductive material for scientific trials and introduction of species in exotic area.

(iii): For the establishment of genetic bank, expansion herbaria, good supply of seed is needed.

(iv): It is desirable to collect the seeds of good quality. In few cases the seed year of the tree has great bearing on seed population both morphologically, physiologically as well as genetically.

(v): Seed is a basic tool to secured food supply and the seed principle means to secure crop yield in less favourable production area (Feistriger, 1975).

Seed collection from fruits was done during the year 2004, from the month of April to July. The collection of seeds of all the eight species i.e. *Albizzia lebbek, Albizzia procera, Butea monosperma, Dalbergia sissoo, Leucaena leucocephala, Holoptelia integrifolia and Azadirachta indica* have been made in the year 2004 from

forests of Bangawa, Chandpura and Laxmanpura which are situated in Jhansi district of U.P. and Tikamgarh district of M.P. round about 20 km distance from Jhansi centre..

To obtain a composite mixture of seeds in each case, atleast ten trees of sound health and fertile age group have been identified from different sites of these forests. Later the seeds are cleaned, mixed together, dried in open sunlight and stored at room temperature in the sealed and airtight polythene bags after proper chemical treatment.

TABLE : 3A LOCALITY OF SEEDS COLLECTION OF SELECTED FOREST TREE SPECIES

S. No.	Name of species	Vernacular name	Family	Locality	Month of seed collection
1:	*Albizzia lebbek*	Siris	Leguminosae; Mimosoideae	A	March:april
2:	*Albizzia procera*	Safed siris,	Mimosaceae; Mimosoideae	A	April-May
3:	*Azadirachta indica*	Neem	Meliaceae	D	June-July
4:	*Butea monosperma*	Dhak, Palas	Leguminosae ; Papilionaceae	A, B	April-June
5:	*Dalbergia sissoo*	Shisham	Leguminosae; Papilionaceae	D	April-June
6:	*Holoptelia integrifolia*	Chiraul	Ulmaceae	D	May-June
7:	*Leucaena leucocephla*	Su-Babul	Leguminosae; Mimosaceae	C	Feb-May
8:	*Tamarindus indica*	Imli	Leguminosae; Caesalpinoideae	D	April-May

*** A = Bangawa forest**
*** B = Chand Pura forest**
*** C = Laxman Pura forest**
*** D = Naya Khera forest**

MATERIALS AND METHODS

Part 1

The knowledge of the period of seed maturity, ability to recognize mature seeds and their dispersal behaviour are some prerequisite for collection of healthy seeds of any species.

1. **Seed collection:**

The propagules of trees in tropical deciduous forests are found lying over the forest floor either in dehiscent or indehiscent forms. In trees like *Dalbergia sissoo, Holoptelia integrifolia* and *Leucaena leucocephala*, the dehiscence of fruits takes place and the seeds fall down on the ground. On the other hand in tree species like *Albizzia lebbek Albizzia procera, Azadirachta indica, Butea monosperma* and *Tamarindus indica* the seeds remain in the locule of hard woody fruit and are dispersed as such.

Seeds collection from fruit was done during the year 2004, from the month of April to July.The seeds of *Albizzia lebbek, Albizzia procera, Azadirachta indica, Butea monosperma, Dalbergia sissoo, Holoptelia integrifolia, Leucaena leucocephala* and *Tamarindus indica* were collected from forest areas of Bangawa, Chandpura, Laxmanpura and Nayakhera situated in the range of Jhansi district of U.P. and Tikamgarh district of M.P. found round about 20 km distance from Jhansi centre. Atleast ten individuals of parent trees of each species were selected for collection of seed /fruit to get a composite sample with a view to include different seed types. Composite seeds/ fruits of each species after cleaning, drying and chemical treatment were stored in sealed polythene bags at room temperature.

2. **Dimensions:**

From the composite sample of seeds, collected from each of the four forest sites in case of all the forest species, the seed and the non seed components were physically separated. After separation, 100 seeds of each of the 8 forest species were weighed individually i.e. single seed at a time, on monopan electric balance and their weights were recorded.

3. Treatment of seed/Fruit:

Seeds of *Albizzia procera, A. lebbeck, Azadirachta indica, Butea monosperma, Dalbergia, sissoo, Holoptelia integrifolia, Leucaena leucocephala* and *Tamarindus indica* were collected in period from April to June except *Leuceana* and *Azadirachta indica* which were collected in period March and first week of July respectively.

Seeds of *Albizzia procera, Albizzia lebbeck, Butea monosperma, Dalbergia sissoo* and *Tamarindus indica* were divided into five lots. The first lot comprised of unsoaked seed, seeds of second lot were soaked in water for 24 hours and of third lot were treated with hot water (80^0 C) and cooled to room temperature for 24 hours. The seeds of last lot were mechanically rubbed to rupture hard seed coat.

Seeds of *Leucaena leucoephala* were dipped in Conc. H_2SO_4 for 1, 2, 3, 4 and 5 minutes and then soaked in normal water for 24 hours. The unsoaked seeds were treated as control. Observations were made on seedling growth after 20 days of germinated seeds.

The collected of seeds of *Azadirachta indica* were depulped immediately after collection. The seed were stored after drying in shade for 5, 10 and 15 days then stored in containers. The seeds of *Azadirachta* and *Holoptelia* do not need scarification.

4. Assessment of seed viability :

In all tests performed to assess viability of different forests tree seeds, minimum 4 replicates of 100 seeds were taken and the results were expressed in terms of mean values.

Assessment of seed viability has been done in two ways –

1: Cutting Tests: It is the most inexpensive test for testing viability in many countries. The simplest viability testing method is directly eye inspection of seeds. Seeds were presoaked in water for 24 hours and then cut longitudinally in two halves with help of sharp scalpel. Cut halves were placed on the glazed glass plates for further observation. The evaluation was done by naked eye to find out the sound, empty and immature seeds in the sample. Healthy seeds has normal colour of endosperm and well developed embryo which has been considered viable and seeds without embryo or abortive embryo

or with milky, mouldy, decayed, shriveled, diseased or insect attacked seed are considered as non viable.

2: Biochemical Test: The biochemical test of seed viability was done by 2,3,5 triphenyl tetrazolium chloride.

(1) 2, 3, 5: Triphenyl tetrazolium chloride is a light yellow; water soluble powder aqueous solution of this salt was prepared. To get the 7 pH, TTC salt was dissolved in phosphate buffer solution prepared in the following way:

Solution 1: 9.078 g of KH_2PO_4 dissolved in 1 litre of H_2O

Solution 2: 11.876 g of $Na_2HPO_4 .2H_2O$ dissolved in 1 litre water 400 ml of sol. 1 mixed with 600 ml of solution 2 gave a buffer of ph 7. 10 g of TTC powder was dissolved in 1000 ml of this buffer. From this stock solution various dilutions were made. The stock solution was stored in amber coloured glass bottle in dark at room temperature and was used for staining up to 6 weeks. Generally 400 seeds in 4 replicates of 100 seeds were used in each test except in some cases where 200 seeds were randomly picked up from a bulk and equal number of seeds was also kept simultaneously for germination test.

Preparation of seeds for staining

(A) Premoistening of seeds: Premoistening is necessary to make the seeds soft enough to be decoated. Seeds were imbibed in water by placing between moistened filter paper for up to 8 hours (ISTA, 1976 Rule. 6.5 2A). Hard coated seeds were scarified and then soaked in water. Seeds were bisected with the help of a sharp blade or razor while still on the blotter. Of these the seeds were lifted using forceps or fingers one by one and then immediately transfer in staining solution to avoid drying. In few cases where seeds were swollen, seed coat was removed with the help of forcep, needle, blade, thumb nail etc. Then seeds were placed on moistened filter paper

(B) Staining of seeds : Seed were kept in water after decoating and later on completely dipped in the TTC. at 35° C in an oven (darkness) ISTA (1983).

Evaluation :

After the desired period of staining, TTC solution was drained off and seeds were washed several times with water and evaluation of colour staining was done.

5. Laboratory :

Four hundred seeds / fruit were placed on the tray covered with sterilized and moistened germination paper in a germinator at 27 ± 2^{0}C and 90^0 humidity.

6. Imbibition :

The seeds were imbibed in glass beaker containing sterilized water for 3,6,9,12,24 and 48 hours in an incubator at 27 ± 2^0 C. The imbibed seeds were then germinated on sterilized and moistened germination paper in seed germinator at 27 ± 2^0 C and 90% humidity.

7 Seed Storage:

Mature seeds of forest species were collected and stored at different temperatures. Seeds of one lot of each species were kept in air tight bottles at room temperature of 20-40^0 C and were stored at room temperature. The highest relative humidity occurred between August to October and lowest between April to June. Viability of seed was expressed by average results of germinability and 2, 3, 5 triphenyl tetrazolium chloride test. Viability test was conducted after a period of one year of storage.Five replicates of 100 seeds of each lot were surface sterilized by soaking in 1% mercuric chloride solution for 5:10 minutes and then germinated in petridishes in laboratory and in earthen pots under natural conditions. For the treatment with 2, 3, 5 triphenyl terazolium chloride seeds were randomly taken from each lot and soaked in water over night. Soaked seeds of each lot were treated with one percent aqueous solution of 2, 3, 5 triphenyl chloride. Well stained seeds were evaluated as viable seeds.

8. Seed sowing :

The seed were uniformly sown (0.5 to 1.5 cm depth depending upon the size of seeds/fruits) in 1 ×1 meter area of nursery, Bangawa forest nursery with due permission of the forest department, Jhansi. The nursery is situated on the eastern bank of river Betwa and is about 15 km. from Jhansi on Jhansi – Mauranipur road.

9. Effect of temperature

Studies on the effect of temperature on seed germination was done in different constant temperatures by using seed germinator in the laboratory of the department. The various temperatures used for such purpose were 20^0 C, 25^0 C, 30^0 C, and 35^0 C.

Part – II

Seeding Growth Studies :

1. **Choice of Species :** The following species were selected to study the growth of seedling – *Albizzia lebbek, Albizzia procera, Azadirachta indica, Butea monosperma, Dalbergia sissoo, Holpotelia integrifolia, Leucena leucocephala* and *Tamarindus indica,* These species were selected on the basis of their dominant or co-dominant nature in the forests of the study area, their use in the purpose of afforestation and reforestation practices and easy availability of seeds.

2. **Potting media:** Effect of different combination of red soil, black soil sandy soil as different potting media were studied in all the eight selected forest species. Eight potting media were prepared by mixing black soil, sandy soil and red soil in different proportions. The media may be prepared as follows –

(a)	Red Soil	(S_1)
(b)	Black Soil	(S_2)
(c)	Sandy Soil	(S_3)
(d)	Sand + Red Soil	(S_4)
(e)	Red + Black Soil	(S_5)
(f)	Sand + Black Soil	(S_6)
(g)	Sand + Red + Black	(S_7)
(h)	Nursery Soil + Fertilizer	(S_8)

Polythene bags of 15X25 cm were used for growth of seedlings of the said species for different combinations of media. Atleast 5 seeds were sown in each bag. Regular watering was done to these sets to provide them sufficient water levels.

3. **Effect of different light conditions** : Three light conditions namely, full sun light, Semi shade and Diffused light have been used to observe the effect of light intensity on seedling growth in different species. To conduct this light experiment, ten polythene bags filled with nursery soil and manure were used and two seedlings raised in each bag. For semi shade condition, the bags were kept under tree canopy and for

diffused light; hut lobby is used to place the bags. The light intensity in the three conditions is measured by Lux meter, indicating 100%, 45% and 20% intensity in open, semi shade and diffused light condition, respectively. The bags with growing seedlings of respected species were shifted in different conditions of light at the age of 20 days.

4. **Irrigation:** The well established seedlings (of about 20 days old) were used to observe the effect of different irrigations. The experiments were conducted in the nursery and the size of polythene bags, soil composition and sowing methods were the same as in above experiments. Three different irrigation conditions (daily-I, Alternately- II, weekly-III) were tried on seedlings. Ten bags (with two seedlings each) were used as replicate for each water regime and the experiment was continued for one year.

5. **Growth hormones:** About two months old seedlings were treated with IAA and IBA at six different concentrations viz 25, 50, 75 and 100 ppm. Plants under control (c) were treated with distilled water in the same way as with growth regulators. Ten replicates (polythene bags of "6x12" size with two seedlings in each) were used for each treatment. These sets were kept under open sunlight. The foliar spray of different concentrations were done weekly from 27 September to 27 December 2005 (for a period of 14 weeks with 14 sprays).

After the completion of these experiments, the seedlings were carefully dugged out. 10 in potting media, 10 seedlings in light and 10 seedlings for growth regulators for all species were randomly selected for the measurement of root, shoot and plant length, dry weight, moisture percent and root shoot dry weight ratio of all the species.

RESULTS AND DISCUSSION

Part – I

Seed Germination :

Germination of seed is an important phase in the life history of any species that determines the potential of that species to spread, in favourable condition for establishment.

Germination is the out come of the interaction of various environmental factors with the intrinsic capabilities of the seeds. The initial step in the germination is the reactivation of systems conserved during the seed maturation period. Arousing a dry seed to start growth into a new plant involves four processes::

(i) The imbibition of water.

(ii) The activation of enzyme system.

(iii) The commencement of growth and radical emergence, and finally.

(iv) The growth of the seedling and its establishment.

The environment has a profound effect on the germination behaviour, which is brought about in two ways. The environment affects both the process of seed development as well as seed germination. Thus germination process is controlled by a combined influence of the environmental factors. However, exact mechanism of this interaction of environment and seed development is still to be worked out The major conditions necessary for germination are access to water, a suitable range of temperature, presence of oxygen and in some seeds the exposure to light. It is suggested that the environmental factors control germination by acting on specific sites of metabolic sequences.

The germination of seed is variously defined. Some of them are as follows:

- "Seed germination is the resumption of physiological activity by dormant embryo inside the seed." Anonymous.
- "That group of processes which causes the sudden transformation of dry seed into the young seedling." A.N. Mayer and A. Poljakoff–Mayber.

- "Germination is reactivation of growth, triggered by environmental stimuli as simple as availability of water and oxygen, or as complex as temperature-light-endogenous inhibitor and promotor interaction." W.T. McDonough.

The life cycle of a plant begins with seed and ends with seed. It is said that seed is the greatest miracle ever created by nature. A seed only a few milligrams in weight poses an admirable programme for creation of huge tree weighing several tones. This programme controlled by the chromosome of seed embryo, starts its precision work in co-operation with the environment, when suitable conditions for seed germination are provided.

"Seed is a highly organized packet of energy that provide for the complete development of the primary plant body, the emergent seedling (M.C. Donough (1977)" containing the new plant in miniature equipped with structure and physiological devices to fit in for its role as a dispersal unit, the seed is well provided with reserve food which sustains the young plant until a self sufficient autotrophic organism can be established (Bewley and Black, 1978).

Seed germination is an important determinant for the population of a species to maintain itself in the environment they grow. In a very simple way, the seed germination is the resumption of physiological activities by dormant embryo inside the seed. Seed germination process is variously affected by the internal condition of the seed and various external factors. Among the environmental factors light, moisture, temperature and soil or substratum effect the seed germination.

It is suggested that environmental factors control germination by acting on specific sites of metabolic sequence, Mayer and Shain (1974). The use of superior quality seed in forestry is of greater importance than in agriculture because the mistake of using poor quality seed in forestry plantation can be detected after a few decades when the crop raised turn out to be poor expected yield, in the same year.

1. Seed Collection :

To obtain a composite mixture of seeds in each case, at least ten trees of sound health and fertile age group have been identified from different sites of the forests for the collection of seed lot. On the basis of method of collection, the first lots of seeds

collected from branches of tree directly by hand plucking and were collected over bed sheet, by causing a slight hand jerk to the branches. The seeds fell down due to development of abscission layer to the base of their stalk are supposed to be mature ones. The seeds of third lot were collected from ground floor, underneath the tree were called as mixed or soil collected trees.

Soon after collection small sized seeds like *Albizzia lebbeck, Albizzia procera, Dalbergia sissoo, Leucaena leucocephala*, were sown in petridishes, differentiating each lot. On the other hand large sized seeds were sown upon the alluminiun separator used in incubator.

TABLE 3 B PERCENTAGE GERMINATION OF SEEDS OF FOREST TREE SPECIES AS AFFECTED BY DIFFERENT METHODS OF COLLECTION:

GERMINATION PERCENTAGE			
Species	Mature seeds	Immature seeds	Soil Collected seeds
Albizzia lebbek	79 ± 2.31	40 ± 1.18	25 ± 0.77
Albizzia procera	80 ± 2.52	39 ± 2.3	22 ± 0.33
Azadirachta indica	84 ± 1.1	45 ± 1.52	24 ± 1.33
Butea monosperma	82 ± 1.63	41 ± 2.6	18 ± 2.31
Dalbergia sissoo	93 ± 2.4	49 ± 2.6	28 ± 0.01
Holoptelia integrifolia	90 ± 2.6	45 ± 1.8	24 ± 0.6
Leucaena leucocephla	95 ± 1.51	50 ± 1.44	32 ± 0.8
Tamarindus indica	83 ± 1.9	41 ± 1.41	25 ± 1.1

Data revealed that the maximum percentage germination was obtained in mature seeds while it was minimum in seeds collected from the soil. However the immature seeds occupied the intermediate position with respect to their percentage germination.

Results also envisage that the methods of seed collection have greater bearing on the germination behaviour. The low percentage germination in seeds collected in soil can be attributed to loss of seed vigour in due course of time to exhaustion of stored food in respiration which results in lower percentage germination (Bewley and black, 1978)

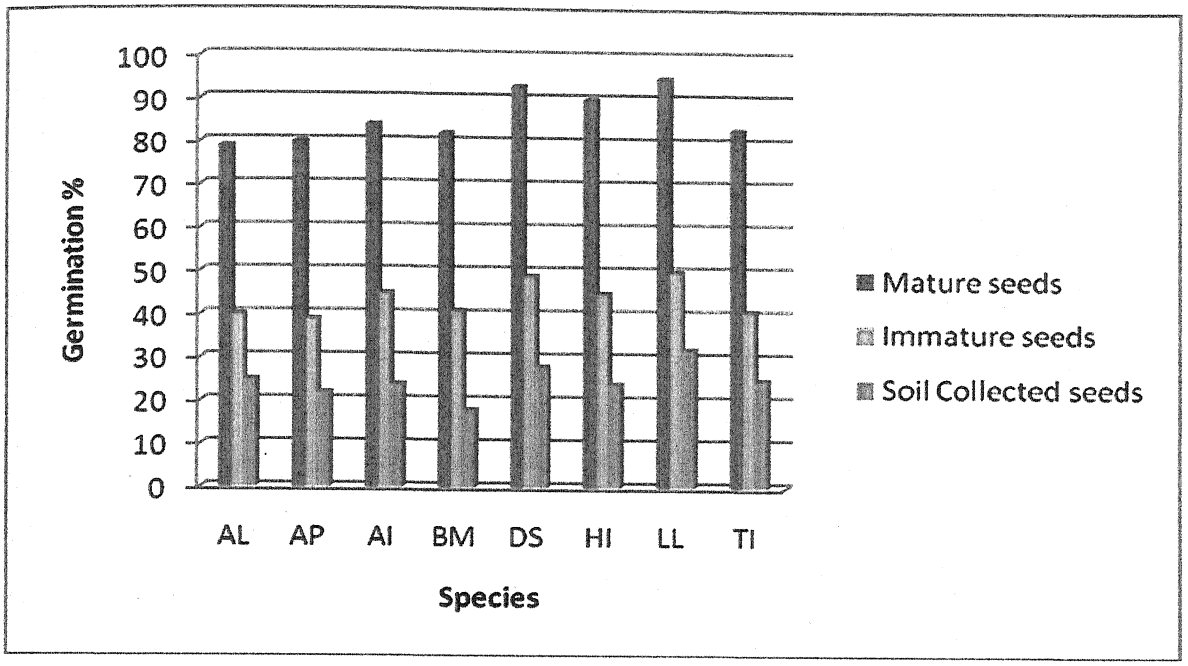


Fig. 2. Percentage germination of seeds of forest tree species as affected by different methods of collection.

Besides this the seeds on the soil surface were also subjected to injury due to the attack of soil microfauna, hoofs of grazing animals and beak of birds.

Mandini (1962) and Aldhous (1972) have reported that first fruits to fall naturally in the season are of poor quality. They have experimented for *Azadirachata indica* and concluded that first fallen fruits took maximum number of days of the commencement of germination. A positive relation was observed between moisture content of the seeds and number of days to commence the germination. It seemed that greater moisture content inhibited the commencement of germination. The differences due to dates and trees were significant for all germination characters and seed moisture content. The date X tree interaction was also significant indicating differential pattern for the germination characters on different dates by different trees.

2. Seed/Fruit Dimension :

Dimensions of seeds / fruits have varied considerably from species to species, as is evident from the parameters of seed / fruit dimensions of selected eight forest species [Table no. 4(A)]. Among all the eight species, the seeds of *Butea monsoperma* were found to have maximum weight (1.11g) while the seeds of *Holoptelia integrifolia* (0.02 gm) has minimum weight. On considering length and breadth, seeds of *Holoptelia integrifolia* (0.72 cm in length) exhibits minimum values of all the parameters.

TABLE : 4(A) SEED DIMENSIONS OF SELECTED IMPORTANT FOREST TREE SPECIES. VALUES ARE MEAN± S.E.

Species	Weight(g)	Length(cm)	Breadth(cm)	L/B ratio
Albizzia lebbek	0.10 ± 0.34	0.96 ± 0.21	0.66 ± 0.21	0.14 ± 0.0
Albizzia procera	0.15 ± 0.78	0.98 ± 0.21	0.72 ±1.41	1.33 ± 1.41
Azadirachta indica	0.42 ± 0.99	1.5 ± 0.66	0.80 ± 0.66	1.87 ± 0.21
Butea monosperma	1.11 ±1.41	4.45 ± 0.4	2.5 ± 0.23	0.21 ± 0.01
Dalbergia sissoo	0.032 ± 0.66	0.82 ± 0.03	0.46 ± 0.33	0.17 ± 0.03
Holoptelia integrifolia	0.02 ± 0.21	0.72 ± 1.41	0.51 ±0.88	1.4 ± 1.41
Leucaena leucocephla	0.45 ± 0	0.94 ± 1.66	0.62 ± 0.76	1.5 ± 0.21
Tamarindus indica	0.52 ±0.66	1.5 ±.66	1.20 ± 0.33	1.25 ± 0.66

Effect of seed weight on germination : Data incorporated in the table no 4(B) reveals the percentage germination of seed of selected forest tree species as compared to that in medium and small weight classes.

Seed weight classes have variable impact on the percentage germination of all the seed species. Table no 4 (B) shows that *Butea monosperma* was found to have maximum germination percentage (61%, 56%,44%) while *Holoptela integrifola* would have minimum germination percentage (18%,16%, and 10%).

TABLE : 4(B) PERCENTAGE GERMINATION OF SEEDS OF FOREST TREE SPECIES AS AFFECTED BY SEED WEIGHT CLASSES. VALUES ARE MEAN ±S.E.

SEED WEIGHT CLASSES			
Species	**Large**	**Medium**	**Small**
Albizzia lebbek	28 ± 2.1	20 ± 2.0	17 ± 1.8
Albizzia procera	26 ± 1.41	22 ± 0.77	16 ± 0.31
Azadirachta indica	45 ± 2.1	40 ± 0.6	33 ± 0.5
Butea monosperma	61 ± 1.6	56 ± 1.4	44 ± 0.3
Dalbergia sissoo	36 ± 1.7	31 ± 0.8	28 ± 0.2
Holoptelia integrifolia	18 ± 1.16	16 ± 1.9	10 ± 0.
Leucaena leucocephla	65 ± 1.16	62 ±1.9	55.8 ± 0.8
Tamarindus indica	56 ± 0.8	49 ± .9	41 ± 1.15

In general, maximum percentage of germination was found in seeds of large weight class than those of medium and small weight classes. It is significant and can be explained or the ground of the higher food content and nutrient pool of the large weight class than the medium and small weight class. As the more reserve good in larger seeds serves as energy source to the developing embryo and its seedling growth while the less reserve food in medium and small seeds attribute to poor germination and retarded seedling growth. The studies of Kandya (1978) and Kandya et al. (1978) on gemination and growth of seedlings on *Pinus caribaea* revealed the occurrence of bigger seeds in

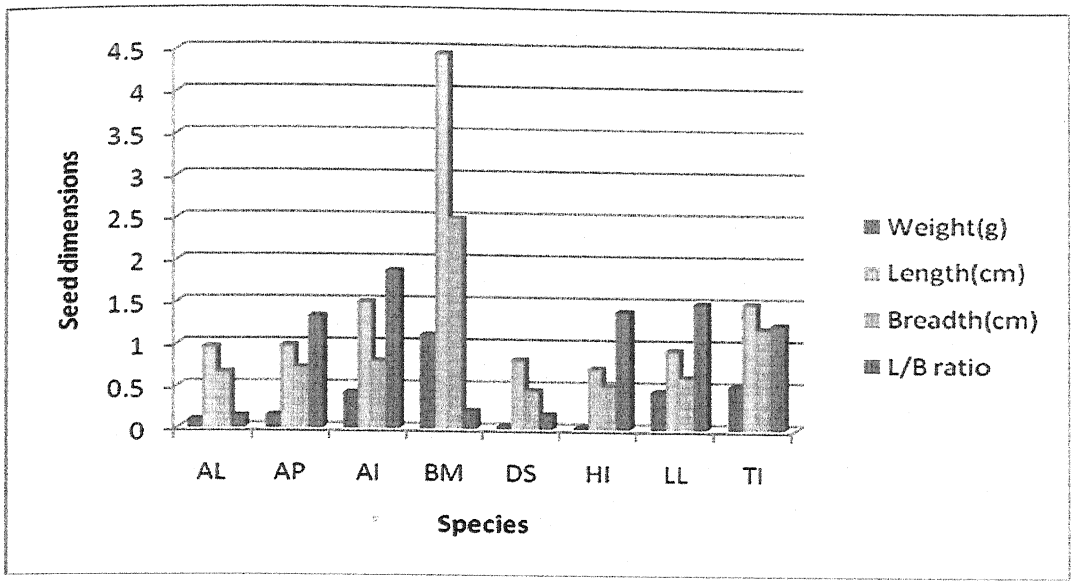


Fig. 3(A) Seed dimensions of selected important forest tree species. Values are mean± S.E.

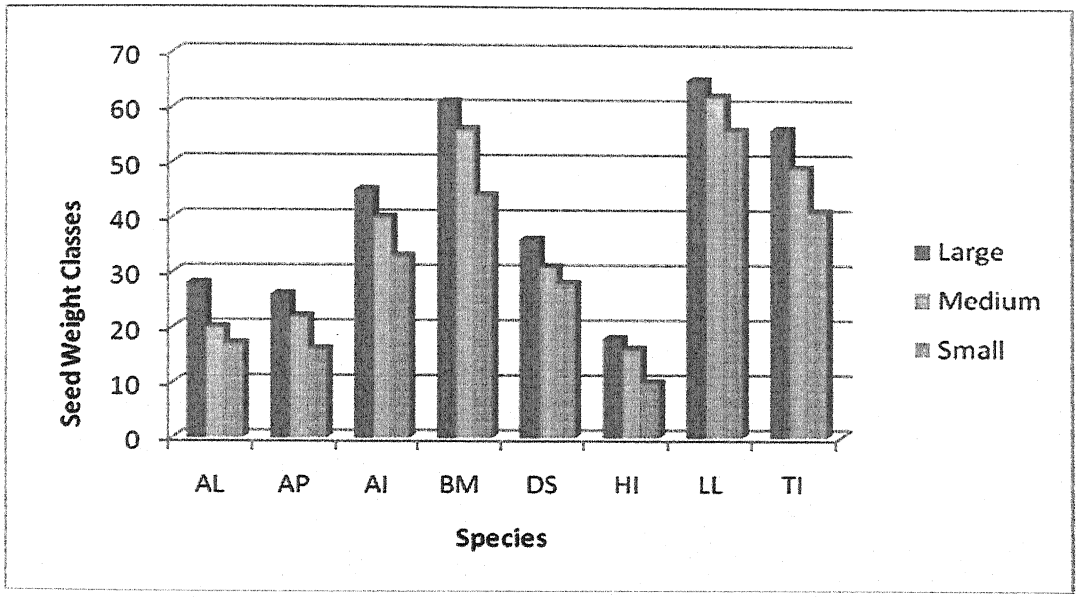
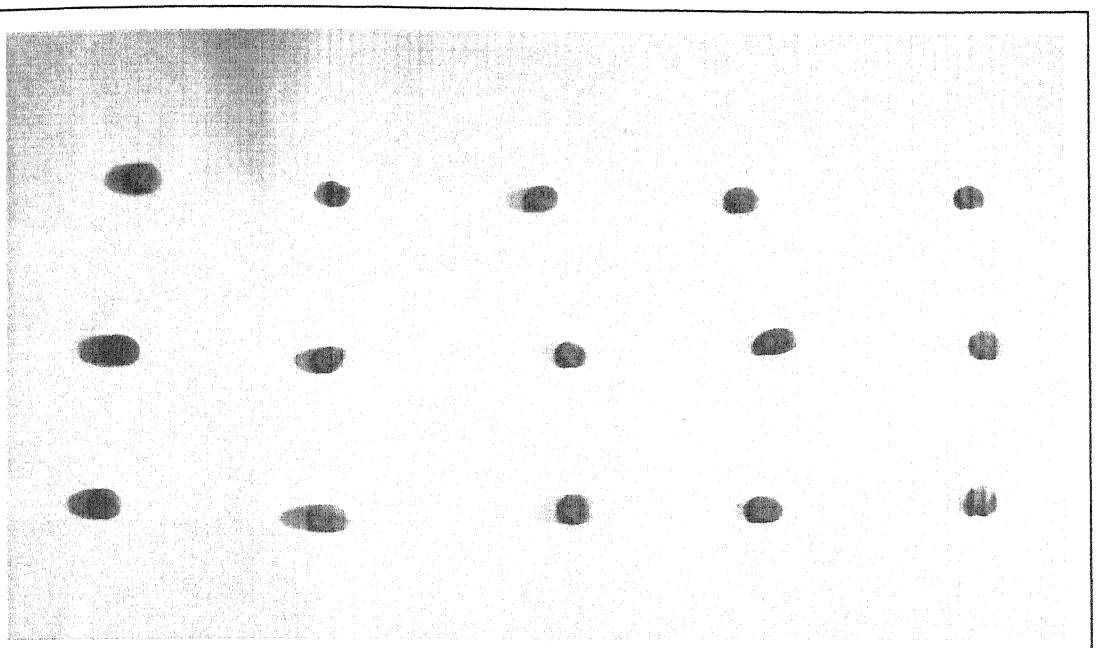
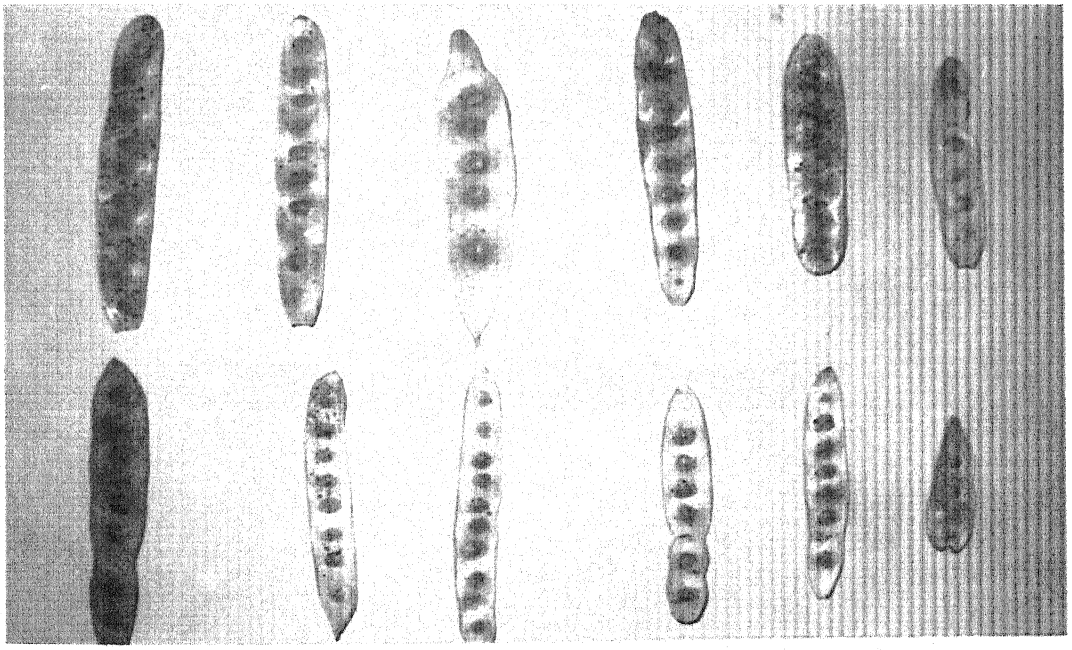


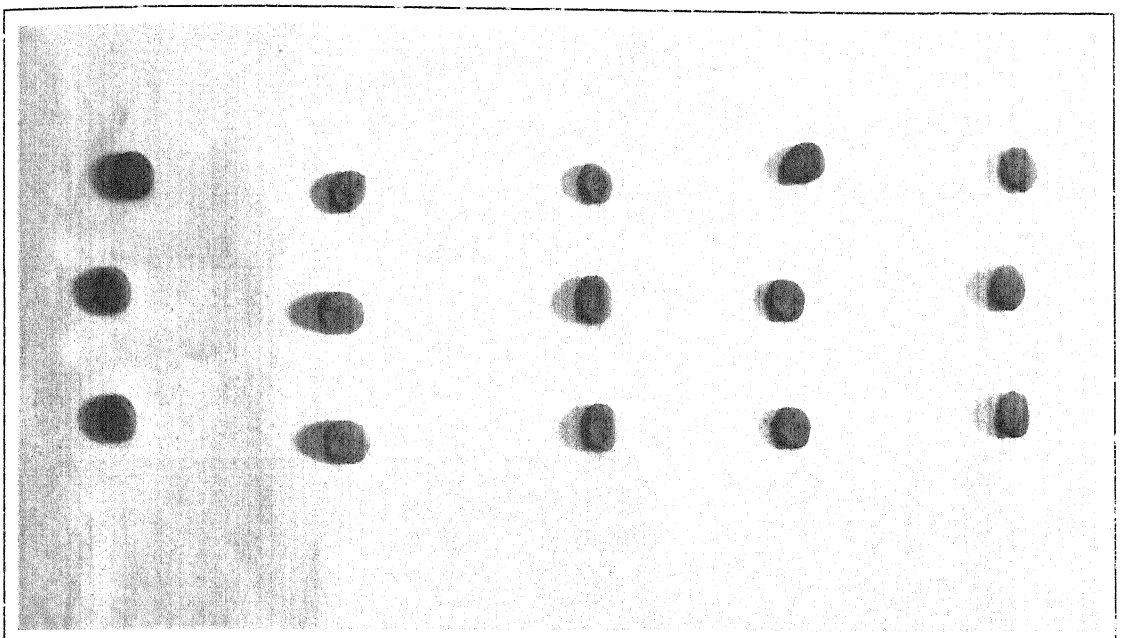
Fig : 3(B) Percentage germination of seeds of forest tree species as affected by seed weight classes. Values are mean ± S.E.



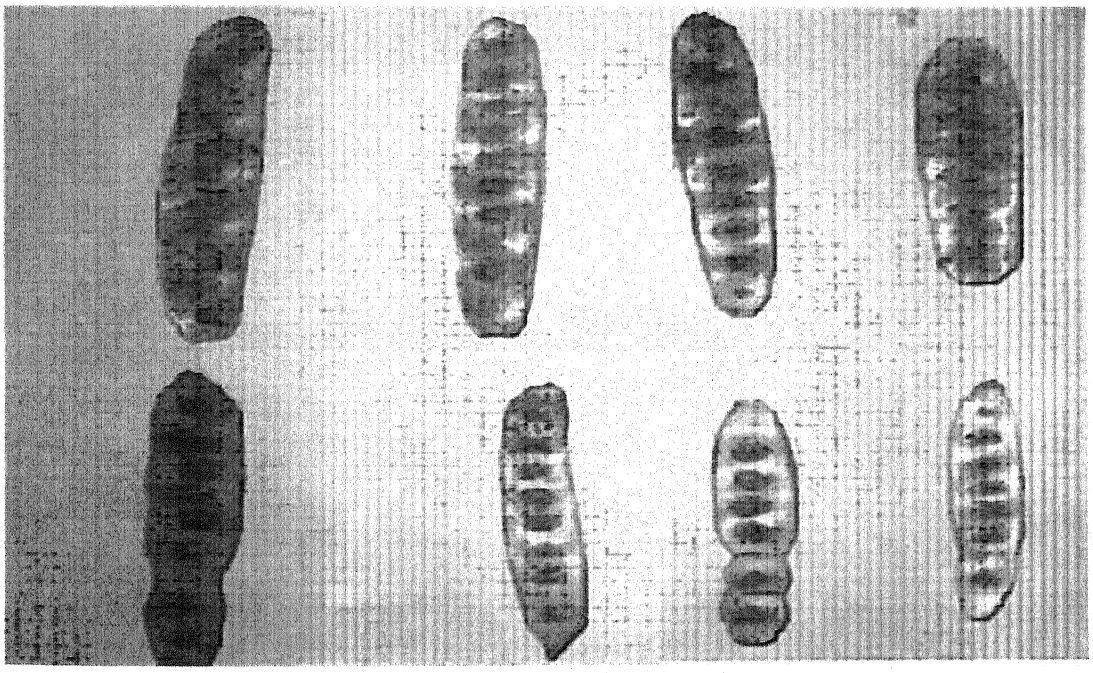
SEEDS OF *ALBIZZIA LEBBECK*



PODS OF *ALBIZZIA LEBBECK*

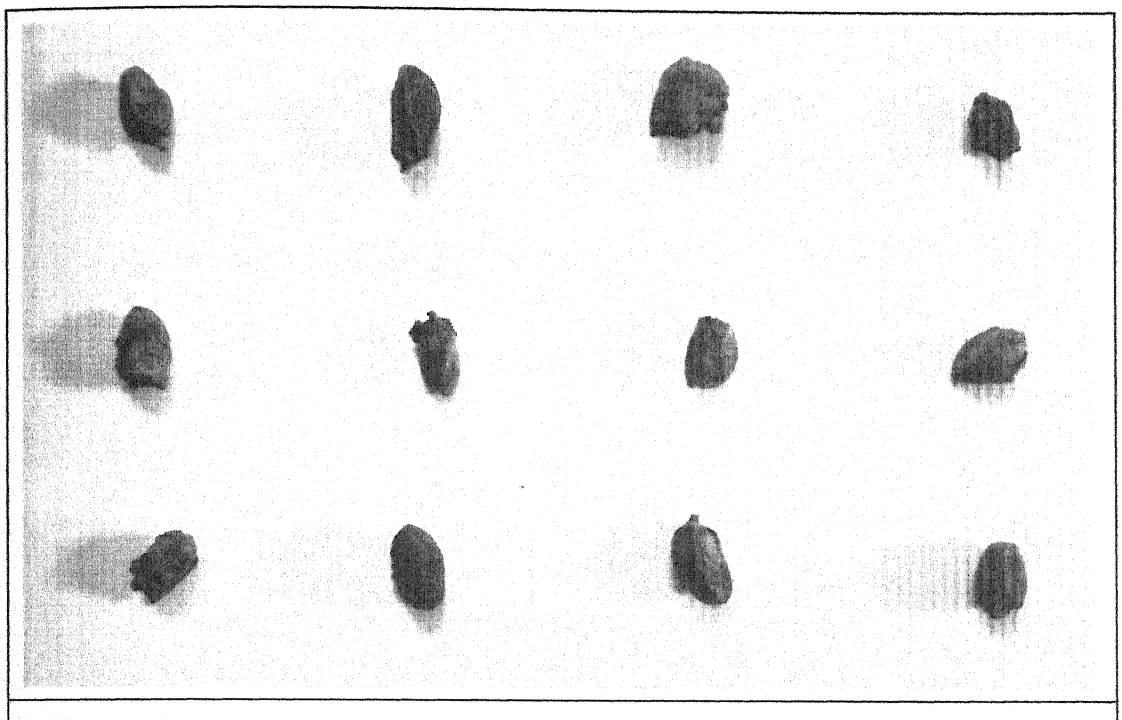


SEEDS OF *ALBIZZIA PROCERA*

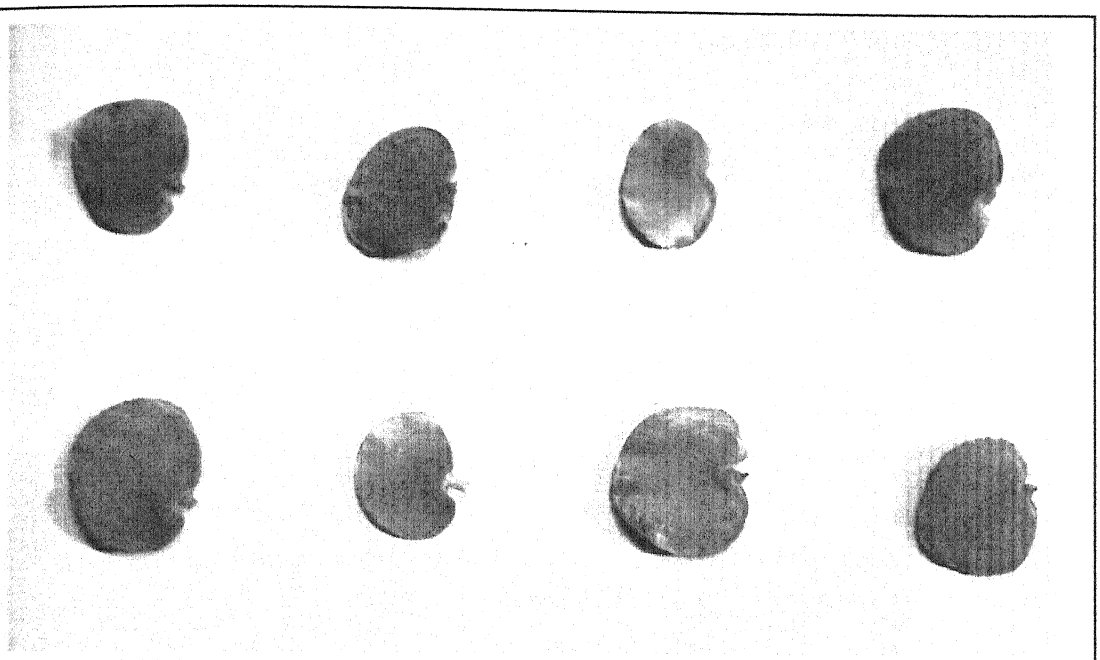


PODS OF *ALBIZZIA PROCERA*

Plate - 11

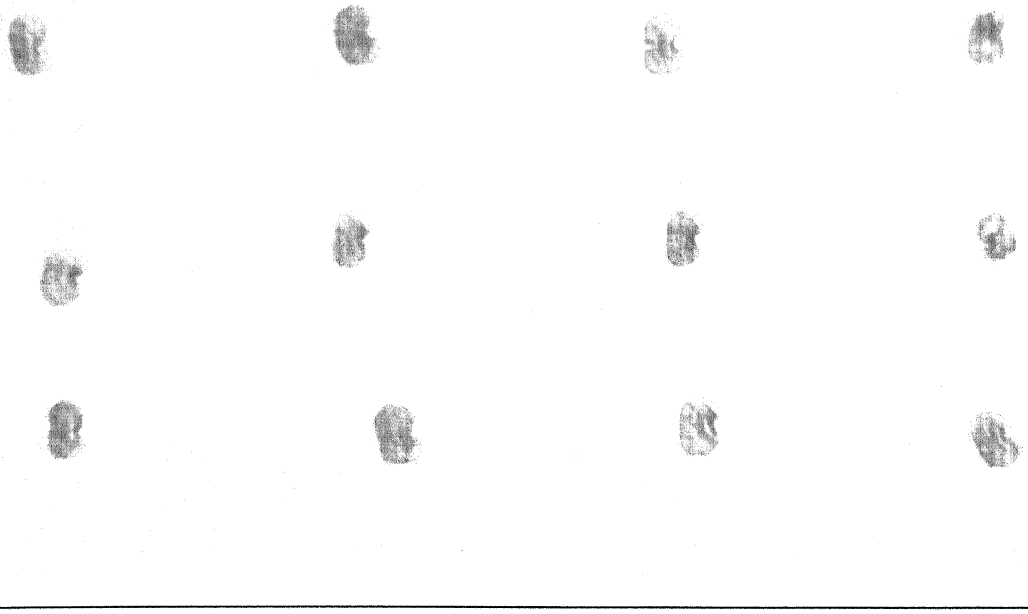


FRUITS OF *AZADIRACHTA INDICA*

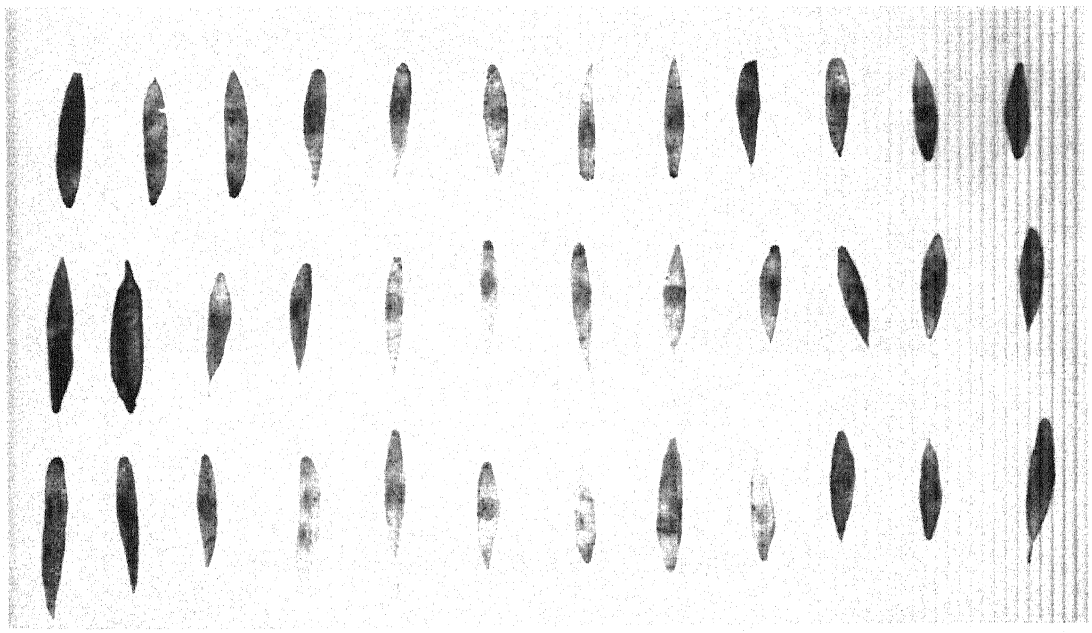


SEEDS OF *BUTEA MONOSPERMA*

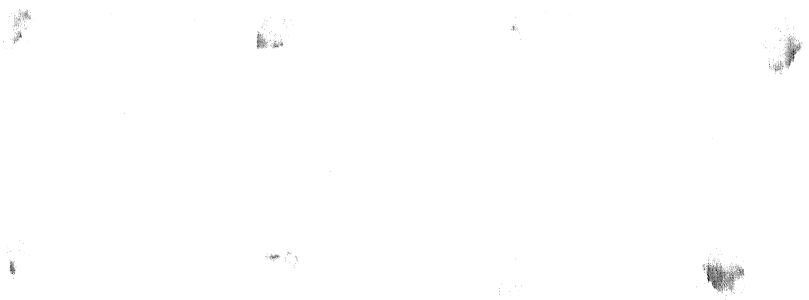
PODS OF *BUTEA MONOSPERMA*



SEEDS OF *DALBERGIA SISSOO*



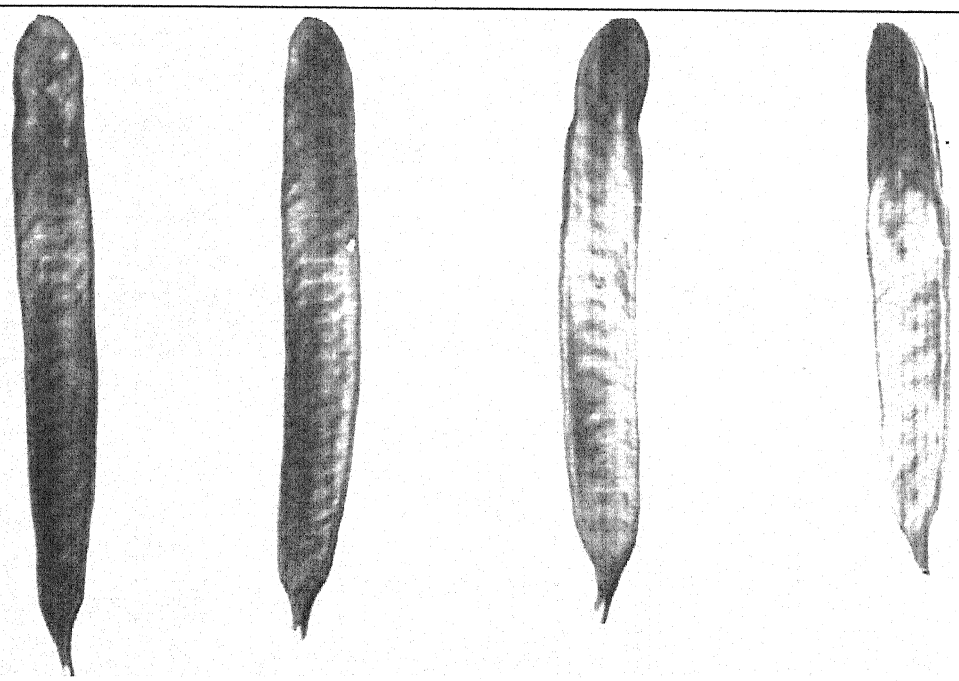
PODS OF *DALBERGIA SISSOO*



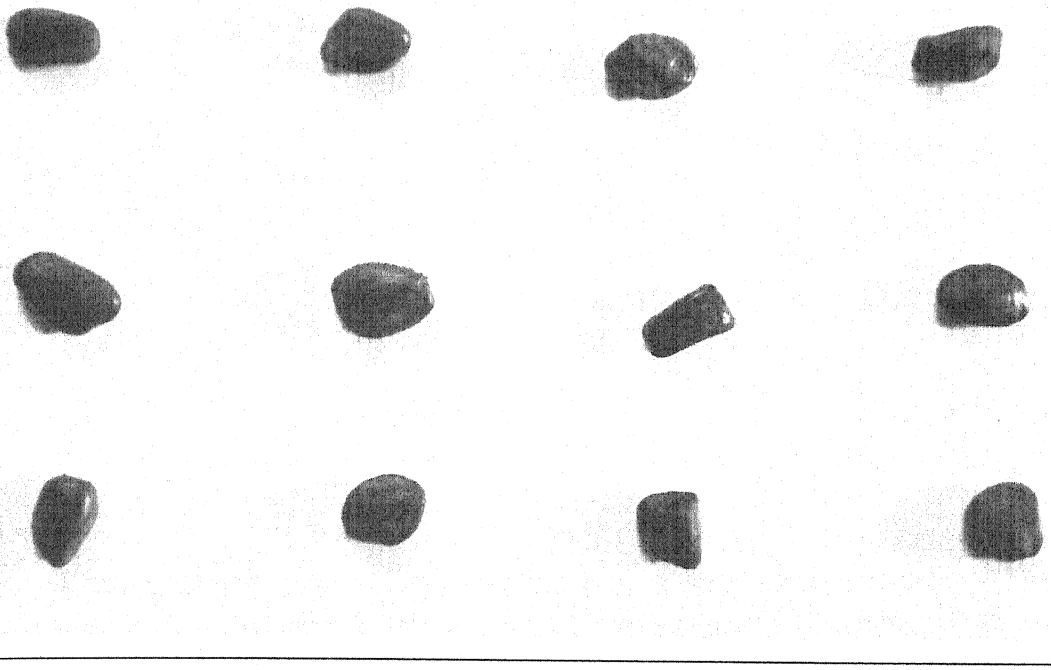
SEEDS OF *HOLOPTELIA INTEGRIFOLIA*

WINGED SEEDS OF *HOLOPTELIA INTEGRIFOLIA*

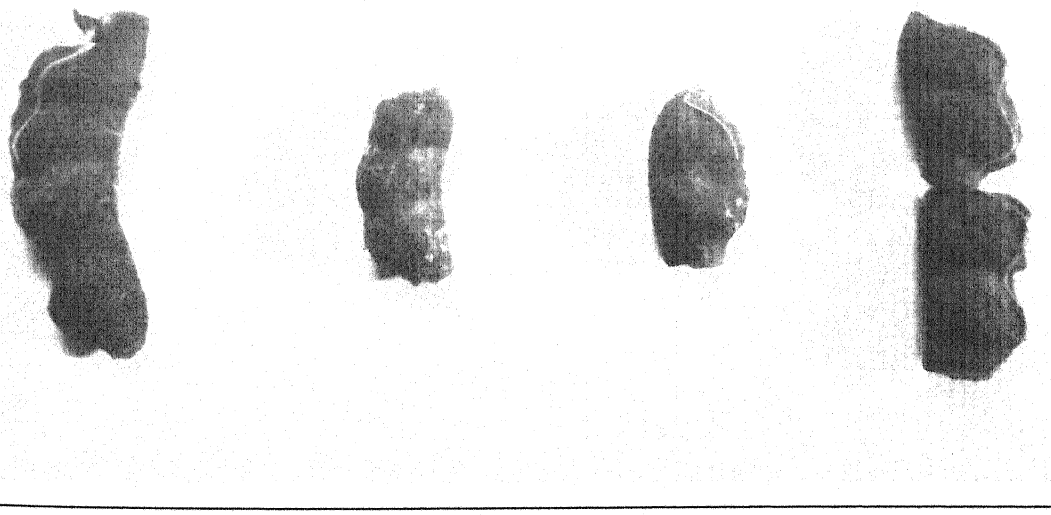
SEEDS OF *LEUCAENA LEUCOCEPHALA*



PODS OF *LEUCAENA LEUCOCEPHALA*



SEEDS OF *TAMARINDUS INDICA*



PODS OF *TAMARINDUS INDICA*

drier areas due to greater endospermic nutrient pool and suggested that the seed weight can be used as a parameter for predicting seedling growth rate in nursery phase of development.

Kandya (1978) has given a strong relationship of seed weight with several growth factors in the early development of *Pinus oocarpa* seedlings. Seed weight was also found to the most important factor affecting the size of one year old eastern white pine (*Pinus strobus)* seedlings. Pauley et al. (1955) found that the heavy seeds germinated early, and the resultant seedlings survived in large proportions than the light seeds. However Pathak et al. (1981) found that in *Albizzia lebbek* the smaller seeds produced the healthy seedlings as compared to large and heavy seeds, the same type of behavior has been observed in case of several field crops by Wood et al. (1977).

Kandya (1978) and Pawley (1955) reported that larger seeds are usually heavier because the size of the seed is a function of the endosperm quantity contained inside the seeds. Therefore fast germination of the seed or fast growth of the seedling in the initial phase may be a reflection of the amount of endosperm or nutrient pool retained in seed. Small size seeds with low seed weight may be helpful in better dispersal, but are disadvantageous as the quantity of its reserve food material concerned.

The effect of seed size for different tree species has been studied by various scientists. In Some species like *Pinus roxburghii* (Chauhan and Raina, 1986). *Morus alba, Quercus rober* and *Q. Velytira* (Koretain, 1927) and *Pinus oocarpa* (Kandya, 1978) investigated a significant co-relation between germination rate and seedling size. Chauhan (1998) has studied the relationship of morpholological variations of seeds with germination behaviour in 20 seed sources of *Bauhinia variegata* and observed that medium sized seed grade gave higher values of initial germination, total germination and germination values in all cases. Gupta et al. (1983) reported that the size usually reflect the comparative nutrient pool and energy of seed which effect the further growth and development of seedlings. Bhardwaj (2001) during the course of studies on germination also observe the similar results of relationship of large size seed associated with higher percentage of germination.

A close relationship between drupe size and germination and subsequent plant development of teak has been reported by several workers (Krishna Murthy 1973; Banik 1977, 1978; Kumar, 1979; Latiff, 1982). Eidman (1984) found that bigger seeds (14 mm

diameter) germinated faster than smaller seeds and showed better growth performance during the first year. Padkee (1967), Shyam (1988), Vishwanath et al. (1995) and Manomani and Vanangamudi (2003) also made similar observations. On the other hand, Agboola (1993) reported that germination rate of small seeds was faster compared to large seeds. Jaya Shankar et al. (1999) found the fact that the seeds size characteristics had no or weak correlation with germination percentage of teak seeds. Generally, large seeds germinate faster and more completely then smaller once. The effect of seed size on germination of loblolly pine (*Pinus taeda*) seed was found to be significant (Dunlap and Barnett, 1984). The seeds germination and seedling value were affected by seed grade in Spruce (Singh et al. 1990). Gupta et al. (1983) find vast differences between large and small seed grades in germination but the smaller seeds recorded fast rate of germination. Ponnammal et al. (1993) obtained the highest germination percentage for *Hardwickia binata* seeds with large size and weight. Darr et al. (2002) have thrown light on effect of seed grading on germination pattern of some multipurpose tree species of Jammu region.

The results have shown that medium size seed grade gave higher values of initial germination, total germination and germination values for all species studied except in case of *Robinia pseudoacacia* , where comparative balance of total seed germination were recorded for small and medium sized seed grades. Mann et al. (2000) have done great deal of work on physiological aspects of seed source variation on seed germination of *Quercus leucotricophora*. They found that provenances differed from each other in mean seed weight, germinability of seeds and seedling growth.

Devarnavadgi and Murthy (1995) have observed the performances of different tree species on eroded soil of northern dry Zone of Karnataka and found that larger seeds were found to germinate faster than the smaller ones and to produce the seedlings where initial growth was greater. Dwivedi and Dyuryagna (1996) have done great deal of work on effect of ecological conditions on morphological variation of seeds of Attai species of Genus *Aconitum* and observed the same results as depicted earlier. Kataki et al. (2001) has studied on variability of pod and seed traits in various species and concluded that pod and seed size has marked influence on germination. Abd-Al-Haki (1994) have studied certain aspects of seedling emergence of *Dendrocalamus stirictus* in relation to seed size and weight parameters and concluded that seed grading before sowing is an efficient and successful method to obtain better yield.

Raj et al. (2001) have recorded_comparative values of total seed germination for small and medium sized seed grades and concluded the importance of medium sized seed for germination as compared to small sized seeds. Kumar et al. (2001) have studied effect of pod and seed size on germination parameters of *Albizzia lebbeck.* It was found that the size and colours have marked influence on germination. Pod size of 8-16 cm length and pod colours of grayed orange group gave highest germination .Similarly seed weight of 6-12g and seed colours of brown group gave highest germination parameters.

Nautiyal and Rawat (2000) have thrown light on the physiological aspects of seeds source variation in certain species and concluded that provenances differed from each other in seed weight and size parameter. Vakshasya et al. (1992) have experimented on datas relating to seed size and weight parameters and found that larger and heavier seeds gave better response as compared to smaller and light weight seeds.

The results of present study is confirmed by the findings of similar studies on other species by Pathak et al. (1981), Gupta et al. (1963) and Singh et al. (1981) indicate that the germination, root length, collar diameter, shoot length, fresh weight and dry weight of different components of the seedlings increased as the seed weight increased in different seed weight classes . The higher growth could be the attribute of large seeds having higher food storage in comparison to the less potential seeds having lower food storage. Though the difficulties of grading the seeds by weight are the major constraints in applying the method, however the seed germination, growth of seedlings and their fresh and dry weight increased with the increase in seed weight as stated by Ponnammals et al. (1993) and Quraishi et al. (1996). Singh et al. (1993) concluded that since the survival and growth was positively related with the size of the seedlings. The large seedlings raised from the large seeds will be given preference for plantation programme which may result in early survival rates in plantations.

The correlation of pod length with pod weight and seed weight per pod and number of seeds per pod was observed by Sharma et al (1994) for *Prosopis juliflora* and concluded that high phenotypic and genotypic variability in pod, seed and germination characters existed within population for best result., Seeds should be collected from trees which gave higher germination i.e. selection of criterion for superior trees should also include performance in germination in addition to Phenotypic characters.

Babeley (1985) found that size of seeds in many conifers have been found to have a controlling effect on their germination and or in the initial growth of the resulting seedlings. Krishnaswamy et al. (1982) concluded that generally large seeds were found to germinate fast and more completely.

Gupta et al. (1983) reported that the initial field emergence and growth rate for the seedlings of *Leucaena leucocephala* was found higher in the larger seeds. Large sized and light weighted seeds of *Lagerstroemia parviflora* are superior as far as their germinability is concerned (Shukla and Ramakrishna, 1981). On the contrary, Ghosh and Sharma (1976) depicts that medium sized seeds gave significantly higher mean total germination percent and plant percent as compared to the large or small sized seeds of *Pinus* species. Again, Kandya (1978) reported a strong relationship of seed weight with several growth factors in the early development of *Pinus oocarpa* seedlings However, an unusual behavior has been reported, where the smaller seeds of *Albizzia lebbeck* gave faster moisture uptake and emergence but low percentage of germination as compared to the large and medium sized seeds (Pathak et al., 1981).

Srimathi et al. (1991) have observed the effect of seed coat colour and seed size on seed germination in *Acacia melifera* and found that large sized and heavy seeds give better response to germination and seedling growth as compared to light weight seeds. Results envisaged by Kandya (1978) Kumar (1979) Chauhan and Raina (1980) Pathak et al. (1981) stated that large size seeds of almost all the species enhanced germination and produce vigorous seedlings.

Seed size and weight plays a vital role in seed germination and behavior because larger and heavier seeds are supposed to possess more nutrients. In some cases weight of seed coat may also be more, but vitality and vigour depends mainly on more nutrient content and a perfect balance in biochemical constituents within the seeds .There is no apparent difference between a dead and living seed but they are differentiated only on the basis of mutual interactions between the metabolized seeds which are responsible for seed vitality and viability. The stresses of habitat and force operating for the perpetuation of the species, affect the seed morphology to a great extent.

The environmental conditions, under which plant is growing, especially during stress, seed morphology is a main character assessing the extent of dispersal of seeds

(Mayer et al., 1963 and Singh, 1968). The effect of seed grading by size on germination and growth of pine seedlings was reported by Ghosh et al. (1976). Result of various experiments have shown that average dimensions of the medium sized seeds give high mean in daily germination as compared be larger and smaller seed sizes, which is quite low in percentage. In comparison to smaller and big seeds, medium sized gave higher mean of daily germination, total biomass, and high root shoot ratio of seedlings .The effect of seed size on germination of *Shorea robusta* plant was reported by Champion (1932). Vanangamudi and Palaniswamy (1988) quoted that plant height is directly proportional to seed size. Separation by seed size has enhanced production of plantable seedlings in some plant species at certain times. The effect of seed size for different tree species has been studied by various scientists. Some species like *Pinus roxburghii* (Chauhan and Raina, 1980) *Morus alba, Quercus robur* and *Quercus velytira* (Korstain, 1927) and *Pinus oocarpa* (Kandya, 1978) has shown significant co-relation between germination rate and size of seedlings.

The fast germination of seeds, fast growth of seedlings at the initial phase may be a reflection of the amount of nutrient pool in the endosperm. Gupta et al. (1983), also reported that the size usually reflect the comparative nutrient pool and energy of seed which affect the further growth and development of seedlings positive co-relations between size and vigour of the plant which support the fact that large or heavier seeds give rise to more better yield, particularly when equal number of seeds per unit area are planted (Bhardwaj, 2001). Generally larger seeds were found to germinate faster and more completely than the smaller ones and to produce the seedlings with greater initial growth.

3. Seed viability :

On the basis of Tetrazolium chloride test the seeds have been classified into different classes. The later is based on the degree of staining, and percent area of embryo taken stain, and unstained necrotic area of the embryo has also been taken into consideration. Thus in all eight classes were made. The fully stained seeds were placed in category 1. Percentage germination of each seed class was tested by TTC method and

actual germination in the laboratory condition. During present investigation, all the selected forest species showed higher viability as depicted in table 5.

Seed viability is determined by tetrazolium test by various workers showed good relationship with viability and germination. Mukherji (1956), Unalcin (1979), Kandya and Babeley (1984), Moore (1985), Buszewicz and Holmes, (1957) considered embryo with about 1/6 of the stained areas as viable. This appears to be correct in many cases, but the area at which necrosis occurs in embryo also seems to be of significance. Lakon (1950) also emphasized the importance of necrosis on the endosperm in the tetrazolium test. Bulat (1957) considered those seeds viable which were having completely stained embryo and endosperm. Further most of the seeds contained decisive tissue, which has ability to repair small superficial necrosis of limited extent even within, "Decisive tissue (ISTA, 1983). From the degree of staining of embryo, the germination capacity of the seed has been estimated during the course of the present investigation.

Saha et al. (1995) have reported several factors for the short viability period of the seeds of *Shorea robusta*. Similar results have been obtaind by Yadav et al. (1988) in the seeds of *Chloroxylon sweetiana* (Bhirra). They have determined seed viability by tetrazolium and indigo carmine staining. Neljeebo (1925) studied that indigo carmine stains dead or dying tissue of the embryo readily but leaves the living tissue unstained.Babeley and Kandya (1986) have used Triphenyl tetrazolium chloride for rapid testing of Viability of *Lagerstroemia parviflora* and many more plant species.

TABLE 5. COMPARISON BETWEEN LABORATORY GERMINATION AND VIABILITY OF SEEDS DETERMINED BY TETRAZOLIUM TEST IN DIFFERENT FOREST SPECIES

Species	Percentage Viability as tested by TTC	Actual percentage germination in Laboratory
Albizzia lebbek	65±1.78	63±1.29
Albizzia procera	78.25 ±1.97	79±1.47
Azadirachta indica	83±0.91	82±2.04
Butea monosperma	100±0	100±0
Dalbergia sissoo	93.50±0.29	92.50±1.44
Holoptelia integrifolia	90±1.08	88±0.41
Leucaena leucocephla	93±2.04	91±1.58
Tamarindus indica	79.50 ±0.65	80±0.71

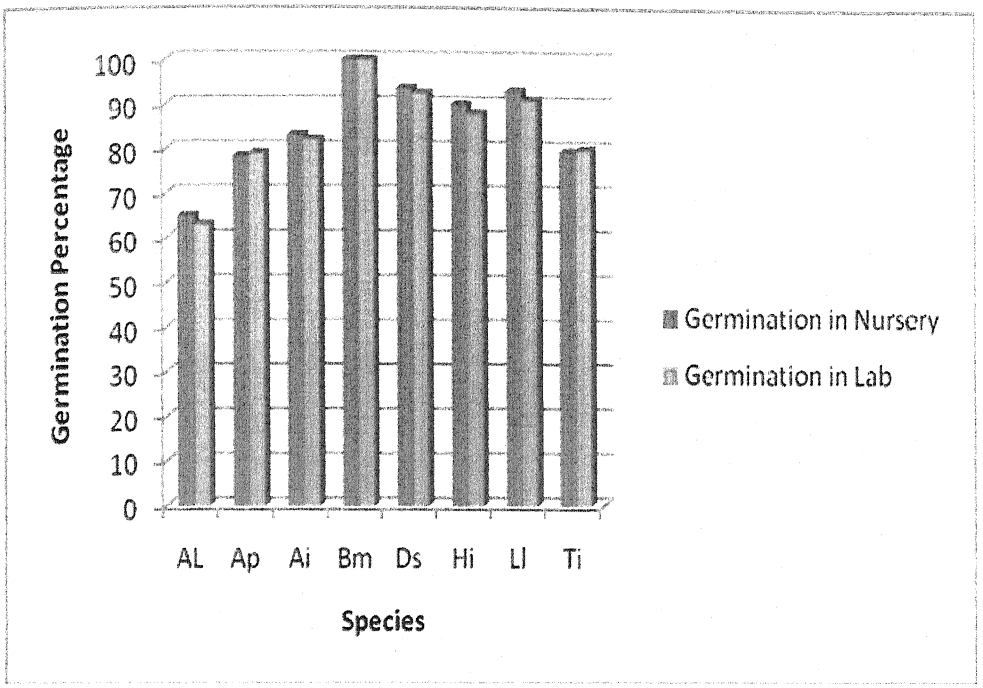
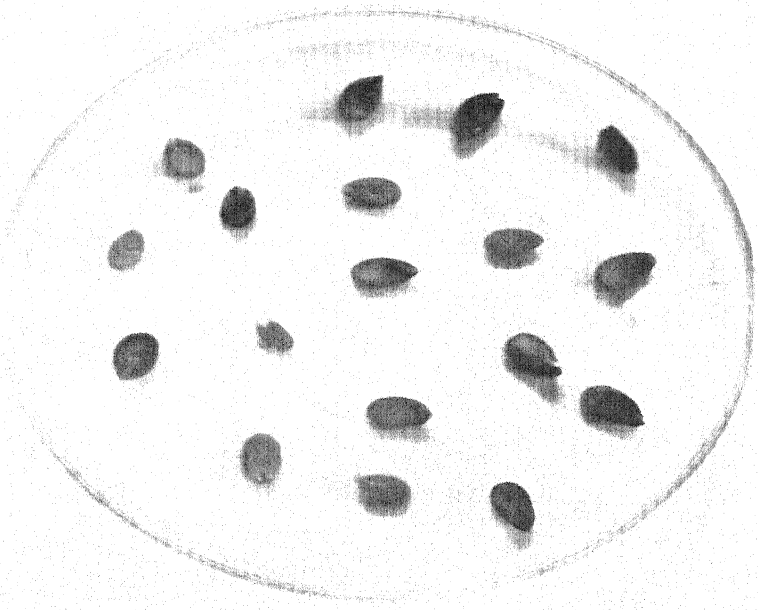
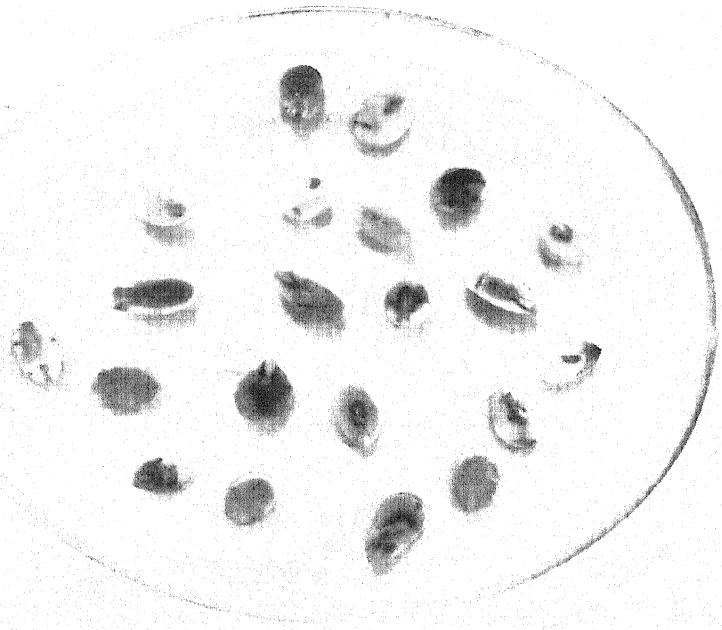


Fig. : 4 Comparision between germination percentage of seeds of selected species at nursery and Laboratory Selected forest species.

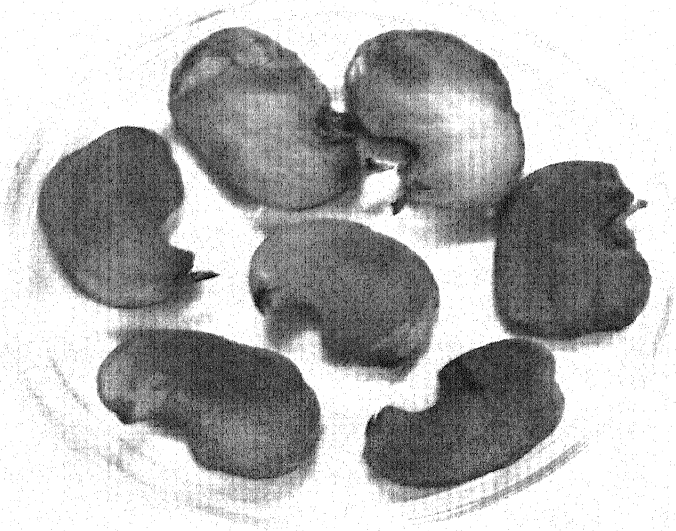


VIABLE SEEDS OF *ALBIZZIA LEBBECK*

VIABLE SEEDS OF *ALBIZZIA PROCERA*

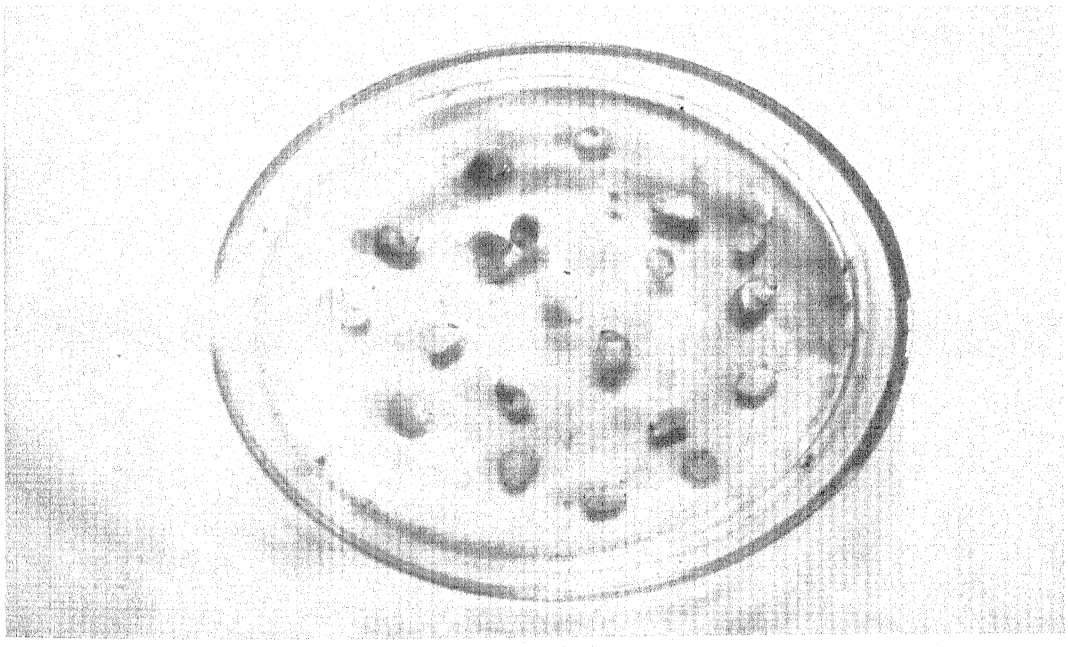


VIABLE SEEDS OF *AZADIRACHTA INDICA*



VIABLE SEEDS OF *BUTEA MONOSPERMA*

VIABLE SEEDS OF *DALBERGIA SISSOO*



VIABLE SEEDS OF *HOLOPTELIA INTEGRIFOLIA*

Plate - 20

VIABLE SEEDS OF *TAMARINDUS INDICA*

Gupta and Raturi (1975) has performed tetrazolium testing of six Indian forest tree species and found the science behind storing seeds for a long time. Generally the colder the storage, the longer the viability time. Gera et al. (2003) have evaluated some cost effective containerized nursery technologies for storing seeds for longer time without loss of their viability. They have suggested improved quality of polybag plants and stressed on the use of MAI beds for nursery germination. Gurudev (1994) has experimented on seed storage and viability of *Toona ciliata* and *Shorea robusta* and found that moisture is the other key factor in keeping seeds viable for longer time.

Similarly, Ebofin (2002), Dutta (1962) and Wave (1976) have reported moisture to be the key factor for the short viability period of seeds of certain species. According to Dent (1948) Neem can be easily reproduced artificially either by direct sowing or seeding transplanting or stump planting but the biggest problem in raising seedling is the short viability of neem seeds. The seeds lose viability within a few days of collection and cannot be stored at low temperature. The seed viability starts detoriating after two weeks of collection. Maithani et al. (1989) have reported that physiologically mature seeds collected from the month of July to early August would express maximum percentage germination as well as longer period of viability. This period coincides with maximum fruit weight and size, embryo weight and size. Moisture content dropped sharply, endocarp becomes fibrous and hard and fruits turn yellow and started falling on the ground.

Maithani et al. (1989) further argued that this stage is easily detectable index of maturity and may be recommended for bulk collection. According to Smith (1989), green cotyledons of Neem will germinate but brown or yellowish would not germinate. Various authors have worked on seed viability of neem seed, like Maithani et al. (1989) reported that the viability of neem seeds can be best maintained in well aerated containers at room temperature or at 15° C up to 6_months. Seed dried in sunlight in glass house for 3 days and stored at 15° C in cotton bags retained viability for more than four months with 62% germination capacity. Same storage results were however obtained by Tiwari 1992, who has prepared a broad monograph on neem and reported that it is a fast growing tree which can grow in wide climatic conditions and can be established easily.

4. Pre-treatments :

Seeds of *Leucaena leucocephala* were treated with conc. H_2SO_4 for 1,2,3,4 and 5 minutes and tested for germination and growth. It is evident from table 6 that seeds dipped in conc. H_2SO_4 for 3 min. had maximum germination. The percentage germination of seeds of Albizzia *procera* and *Albizzia lebbek* was found higher when they were soaked in water at 30°C for 24 hours than that of unsoaked seeds.

The viability of Neem seeds can be maintained upto 6 months if they are dried under shade 5 to 10 days at room temperature after depulping. The viability of the seeds decreased irrespective of the container used for storage. The longer the period of drying under shade, the higher the loss of seed viability as the germination decreased with the increase in drying period under shade.

Seeds of *Butea monosperma* and *Dalbergia sissoo* showed higher germination when soaked in water at 30° C for 24 hours than that of unsoaked seeds.
Seeds of *Holoptelia integrifolia and Tamarindus indica* require no scarification. Direct sowing is more effective in these two species.

Seeds which have hard seed coat reduce seed germination. In present study, hot water treatment was found to be most effective in softening hard seed coat. Even soaking in cow dung slurry was found to be effective. Hartmann and Kaster (1976) opened that hard coated seeds if kept in a non sterile moist warm medium for several weeks get soften due to micro organism action. Similarly the seed coat of *L. leucocephala* got softened with the H_2SO_4 treatment. Similar results were reported by Pathak et al. (1974).

Seed germination and seedling growth in *Albizzia procera* was found to be better in seeds soaked in water at room temperature (30°C) for 24 hours. The soaking of seeds in hot water was found to be harmful, thereby reducing germination percentage. Milat-E-Mustafa (1989) and Bahuguna et al. (1987) also reported higher germination in untreated seeds of *A.procera* as compared to hot water soaked seeds. Contrary to this, the seed germination and seedling growth of *Albizia lebbek* was more pronounced by presoaking in water as compared to unsoaked seeds.

According to Hatano and Asakawa (1964) seed coats have long been considered to be a kind of barrier to water absorption. Such type of impermeability of hard seed coat to water can be overcome by pre- chilling or by scarification. Recently effect of different

methods of scarification on seed germination has been studied in various plants by number of workers namely Verma and Tandon (1984) Hussain, Vasistha and soni (1988) and Rai and Nagaveni (1988). Earlier workers demonstrated the mechanical and chemical scarification in some tree species of leguminosae and found that it is consistently effective in promoting rapid, uniform and high germination as compared to dry heat treatments (Larson, 1964, Oakes, 1984 and Teketay, 1994). Dry and moist heat has also been reported to improve germination (Jefferey et al. 1988). Several workers have reviewed the physiology of seed coat permeability (Ballard, 1973, Tran and Cavanagh 1984, Vasquez-Yanes and Orozko-Segovia,1993). Its ecological significance has been discussed by Fenner (1985), Gutterman (1985) and Takatay (1994). According to them seed coat imposed dormancy is a delayed mechanism, which prevents germination under conditions which might prove to be suitable for establishment.

Mechanical scarification and pre treatment with conc. H_2SO_4 and HNO_3 stimulated germination in *Acacia fernesiona.* (Gill et al., 1986). Rai and Nageverni (1988) during his experimental studies found that in *Ficus benghalensis*, *F. glomurata, F. Myaorensis* and *F. religiosa* soaking of seed for 10 minutes in hot water at 60^0 C gave the highest germination percentage. Vasistha and Soni (1988) stated that sulphuric acid treatment has positive effect on germination of *Trema politician* seeds. Conc. sulphuric acid, hot water treatment and the mechanical scarification were found to be beneficial in breaking the seed coat dormancy and enhancing the germination percentage of seeds of *Prosopis juliflora* (Babely, 1985). For best germination in Teak, soaking of the seeds for 48 hours in water and then followed by an alternative drying and soaking (12 hours each) for 21 days is recommended by Negulube (1988). Kandya and Babeley (1985) reported that hot water treatment was found to give a very good germination and also the higher values of germination in *Leucaena leucocephala* seeds. Babeley and Kandya (1985) while, working on some suitable pretreatment for *Acacia catechu* recommended that seeds of *Acacia* when treated with conc. sulphuric acid for 10 and 15 minutes gave better_results. Mechanical scarification (foiling) and treatment of seed with conc. sulphuric acid produced a handsome number of vigorous seedlings in *Cassia fistula.*

Moist cold stratification is commonly used to break dormancy or improve germination for *Pine* seeds as illustrated by Schubert and Adams (1971). Instances where

the germination of seeds has been adversely affected by hot or boiling water treatment as reported by Delouche (1964), Bewley and Black (1985), Cooper (1986), Kumar (1990), Sharma (1997), Chacko and Pillai (1997). The reverse breakdown of germination mechanism in seeds when soaked in boiling water may be due to lethal action of boiling water (100^0 C) on enzyme activity responsible for initiating germination percentage and germination energy percent. However with the increase in exposure time of seeds in conc. H_2SO_4 for 5 minutes, there was slight decrease in the values of their germination percentage. The conc. H_2SO_4 might have effective to the hard seed coat through its corrosion effect, making the seed coat weaker, soft and permeable to water. Thereby, facilitating the rate of imbibitions and finally the process of early germination.

TABLE 6. MODE OF SCARIFICATION OF SELETED PLANT SPECIES

Name of species	Scarified or not	Premoistening		Staining at 30°C solution %	Staining periods hours
		Type	Time(hr)		
Albizzia lebbek	Yes	W	24	0.1	24
Albizzia procera	Yes	W	24	0.1	24
Azadirachta indica	No	W	24	0.1	24
Butea monosperma	Yes	W	24	0.1	24
Dalbergia sissoo	Yes	W	24	0.1	24
Holoptelia integrifolia	No	W	24	0.1	24
Leucaena leucocephala	Yes	B. W. Conc. H_2SO_4	2-3min 16 h 3 min	0.1	24
Tamarindus indica	No	W	24	0.1	24

* W = Water

* B.W. = Boiling water

Therefore it can be said that long exposure to acids is not suitable in certain species like *Ribes orientale.* The methods of scarification for some untreated seeds in case of

savannah tree legumes were given by Agboola (1955). In this method the oven used was already preset to the temperature value required in each case the seed placed in it. The seeds were allowed to cool and then plated for germination in the laboratory (30± 1° C).

Some of the seeds of tree species have been found experimentally to have physical dormancy due to hard seed coat. In general, seeds with this form of dormancy possesess hard or /thick seed coats, pericarps or other structures that impose a high mechanical resistance on an often non dormant embryo or block water uptake or/ and oxygen differs, only removed (Kelly et al. 1992, Agboola 1995 and Hillhorst 1995) the pretreatments employed are design to soften, puncture, wear away or split the seed coats in order to render it permeable. Harrington (1916) found that the long time acid treatment of seeds leads to poor germination.

5. Storage:

Storage period of seeds affect the germination percentage of seeds, in case of eight selected species i.e. *Albizzia lebbek*, *Albizzia procera*, *Azadirachta indica*, *Butea monosperma*, *Dalbergia sissoo*, *Holoptelia integrifolia*, *Leucaena leucocephala* and *Tamarindus indica*. A careful perusal of these species reveal that the germinability of seeds of all these species exhibit a trend of sharp decline in germination percentage at room temperature with increase in the storage period from fresh seeds to twelve month old seeds. The percentage germination after one year storage was found 75% in *Leucaena leucocephala*, 43% in *Dalbergia sissoo*, 45% in *Holoptelia integrifolia*, 35% in *Tamarindus indica*, 45% in *Azadirachta indica*, 50% in *Butea monosperma*, 45% in *Albizzia procera*, and 50% in *Albizzia lebbek*, as against 90, 93, 90, 83, 85.82,75 and 78 percentage of germination of fresh seeds in respected species.

In all these species, *Albizzia* species were found to be most sensitive for storage. Sometimes Neem too was found sensitive during first four months. In all these plants, a very sharp and district decline is seen when it is compared with four month old seeds. Further the decline is found to be moderate when 4 month old seeds compared with six month old seeds. This decline in germination was more or less insignificant when 6 month old seeds were compared with 12 month old seeds. Overall in all cases, it is evident that prolonged storage period decreases the viability of seeds. The gradual loss of

germination capacity of seeds during storage can be explained due to degeneration of enzymes, decrease of stored food, gradual coagulation of proteins of the embryos and accumulation of the toxic metabolic products as a result of many catabolic physiological processes.

Sibasubramanian (1997) observed that irrespective of colour categories, *Moringa ollifera* seed were stored better in polethene bags than in cloth bags. Black coloured seed store superior by registering higher value for seeds vigour and was followed by brown coloured seeds; where as in white coloured seeds recorded very poor germination.

TABLE 7. COMPARISION BETWEEN GERMINATION PERCENTAGE BEFORE AND AFTER STORAGE IN SELECTED FOREST TREE SPECIES.

Species	Germination Percentage	
	Before Storage	After storage
Albizzia lebbek	78	45
Albizzia procera	75	45
Azadirachta indica	85	50
Butea monosperma	82	43
Dalbergia sissoo	93	45
Holoptelia integrifolia	90	75
Leucaena leucocephala	95	35
Tamarindus indica	83	35

The seed stored at room temperature lost their viability maximally after six months storage. This may be due to the activity of the mycoflora present inside the seed, which becomes active when it gets optional environmental condition during storage. Thus they destroy the endosperm by utilizing it as their substrate and render the seed non viable. The results are in close confirmity with the findings of Gupta and Raturi (1975).

It is well known that *Azadirachta indica* seeds have a short span of viability (Maithani et al. 1989). To retain viability, the seeds were stored for different period under different conditions and containers. It was found that when seeds were stored in cloth

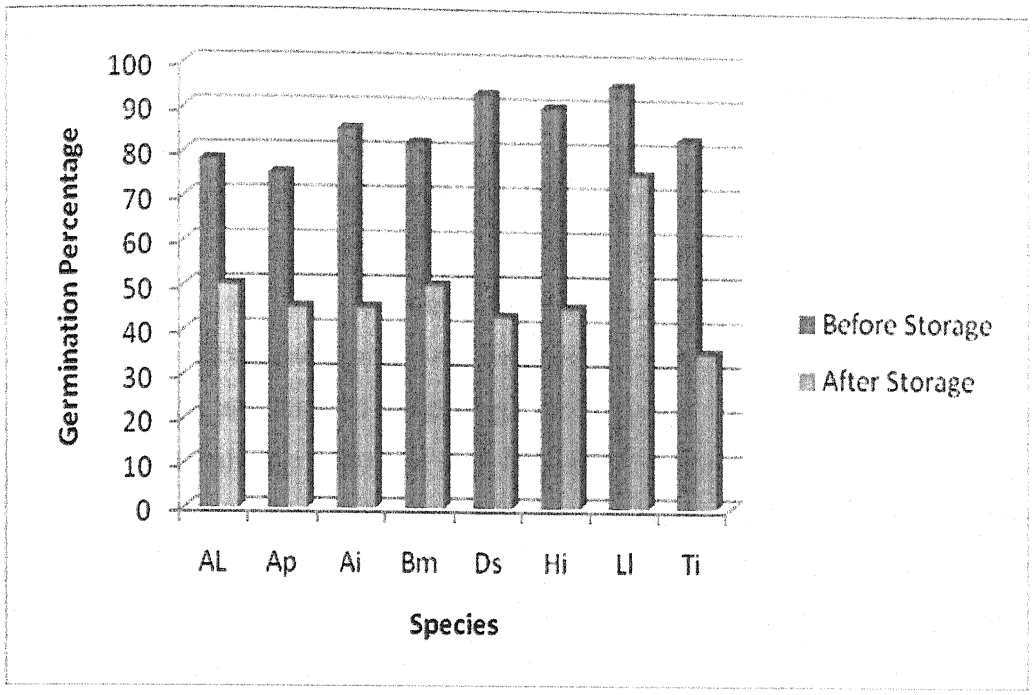


Fig. : 5 Comparision between germination percentage of seeds of selected species as affected by storage period.

bags after drying under shade for 5, 10 and 15 days, the seeds remain viable for longer duration. Although increasing the drying interval under shade reduced the viability. This seems to be due to drying under field conditions where hot winds played effective role in decreasing seed viability and ultimately its germination. The seeds stored under refrigerator (at 7° C) lost their viability due to chilling injury caused by the presence of excess water in the cell cytoplasm.

Seeds of 8 taxa (Kanak Sahai, 1998) when stored in refrigerator maintained their viability for longer period because of low relative humidity and temperature. The important factors which determine the viability of seeds in storage system were seed moisture content and temperature. Seed stored at room temperature lost their viability rather rapidly as compared to those kept in refrigerator and thus affecting their longevity.

Generally the process of seed detoriation was faster and greater at ambient storage but the effect of temperature varied from species to species. Some species lost their viability at room temperature while some lost at low temperature of refrigerator. The continuous storage of seeds of *Dalbergia sissoo* in refrigerator lost their viability while at room temperature they show 35% viability after the same period of storage (six months). Seeds of *Acacia catchu* showed 20% viability at room temperature after the storage of 18 months, while seeds kept in refrigerator showed 80% viability with 100% germination up to the storage of 24 months. Variation in the variability of stored seeds depends on the initial moisture in the seeds and the atmospheric humidity at the time of storage. The rate of detoriation was rather slow under low moisture content. The longevity of seed viability varies from taxa to taxa and even species to species under the same packing and storage conditions e.g. *Albizzia lebbek* showed 5% viability (Stored at room temperature) at the end of 7th year storage while under same conditions, seeds of *A. lucida* lost their viability after 36 months of storage (Schimf, 1977) .

Gupta and Raturi (1975) found that the seeds stored at room temperature lost their viability due to activity of mycoflora present inside the seed. Almost identical findings were reported earlier by Ahmed et. al. (1993) in *Toona ciliata* seeds and Suman (1996) who studied *Populus ciliata* seeds for storing effect. They found that decrease in seed germination was more pronounced during first three months of storage period.

Bhagat and Singh (1994) summarized storage capacity of some temperate shrubs, where the germination capacity is affected by storage period. Result similar to present observation was described by Agrawal and Sharma (1990). Recently Purohit et al. (2000) observed the response of storage period at two range of temperatures i.e. at 20^0 C and 30^0 C on the seeds of *Eucalyptus globulus* and reported that the germination percentage of seeds after one year, two year and three year of storage were 63 and 28, 7 and 58, 19 and 3.8 in foresaid range of temperature, respectively.

Seed viability of *Acacia catechu*, *A. nilotica* and *Cassia fistula* reduced from 60, 90 and 100% to 20, 75 and 85%, respectively at room temperature, after the storage of two years , but no reduction in viability was observed if the seeds of these species stored in refrigerator for the same period. Sunil Kumar and Sudhakar (1998) studied the effect of temperature on the storage of *Hopea parviflora* seeds in Southern India and found rapid decline in moisture content and germination with storage period irrespective of storage temperature. Sahai (1999) also recorded that seeds of *D. sissoo lost* their viability at low temperature. Wilson. (2002) suggested that seed storage reduces vigour than viability. He told that under dry conditions seeds gradually become very weak, yet retained the ability to germinate. At high moisture levels both vigour and viability drop off suddenly (Wilson 1986).

Teak fruits can be dry stored in Gunny bags, Polythene bags (Emmanuel and Dharmaswamy, 1991) sealed containers (Jalil 1994). Teak seeds improve and germinate better by keeping for 1-2 years (Troup, 1921). However, Eidman (1934) noted that viability of teak seeds lasts for only one year. After three years storage in air tight containers (Jalil, 1994) found that very few seeds germinate.

Simak, Milan (1973) on *Pinus sylvesteris*, Song, X (1984) on *Hopea bhainenensis*, Purohit M.N.C pant (1997) on storage of *Albizzia procera*. Krishnapillay (1996) have created alternative methods for storage of orthodox and recalcitrant seeds which have been classified on the basis of their response of water. The orthodox seeds are usually dormant and can retain viability even at very low moisture content. Similarly, Ezumah (1986) Dent (1948) Dass (1971) Devagiri (1998) Dabral (1976) have also worked on physiological processes of forest tree seeds during seed storage and germination and found the fact that decrease in seed germination was more pronounced during first three months of storage

period. Effect of tree age class and dormant behavior of seeds of some important Himalayan trees was studied by Atul Sharma et al. (2002) and found that seeds stored in refrigerator maintained their viability for longer period because of low relative humidity and temperature. The important factors which determine the viability of seeds in storage system were seed moisture content and temperature .Seed stored at room temperature lost their viability rapidly as compared to those in refrigerator and thus affecting their longevity.

6. Imbibition:

Percentage germination of seeds of forest tree species as affected by duration of pre-soaking in water is given in Table 8. There appears a positive relationship between duration of pre-soaking and percentage germination in all the species except for *Butea monosperma* where percentage germination increased up to 6 hours of pre-soaking and then declined. During 48 hours of pre-soaking, maximum germination (72%) was found in *Leucaena leucocephala* and minimum (10.67%) in *Tamarindus indica.*

The pre-soaking of seeds/Fruits in water for a particular time may increase the permeability of seeds/fruits wall to water and gases. As the water enters inside the seed/Fruit, the enzymes which are present inside the seed/fruit become active, and accelerate the germination process. The longer duration of pre-soaking of seeds/fruits appears to be more appropriate for the seeds/fruits for softening the hard seed coat and make it permeable after imbibition, as is evident in the case of *Leucaena leucocephala* and *Tamarindus indica.* On the other hand, the extended duration of pre-soaking in the case of highly permeable seeds may allow more water inside the seeds/fruits which will replace gas (oxygen) resulting reduced respiration thereby reduction in germination percentage of germination, as is revealed by the poor performance of seeds of Butea *monosperma* imbibed for more than 6 hours. Therefore, the presoaking of seeds/fruits for better germination should be made cautiously.

Data on relationship between imbibition and seed germination are interesting and are given in the table 8. Maximum germination percentage was obtained, when the seeds were imbibed of 24 hours in most of the species included in present study. The rate of germination was also achieved at peak when seeds imbibed to the period of 24 hours but a

sharp decline in rate and germination percentage was observed if this imbibition period enhance beyond 24 hrs during their investigation. Similar results have been found by Kidd and West (1918, 1919).

Tourney and Durland (1923) studied the effect of presoaking on a number of coniferous seeds of upland species and found that soaking for more than 3 to 5 days was generally injurious. Resciher (1941) studied that injurious effect of presoaking of seed of soyabean and it has been attributed to higher permeability of seed coat to water.

TABLE 8. DURATION OF IMBIBITION EFFECTING GERMINATION PERCENTAGE:

Species	3 hrs.	6 hrs.	9 hrs.	12 hrs.	24 hrs.	48 hrs.
Albizzia lebbek	12 ±2.31	10.67 ±1.33	10.67 ±2.67	13.33 ±1.33	60 ±2.31	34.67 ±3.53
Albizzia procera	19.4 ±1.33	17.6 ±2.31	15.2 ±2.67	23.82 ±1.33	48 ±0.31	36 ±2.31
Azadirachta indica	4 ±0	4 ±0	5.33 ±1.33	8 ±32.31	20 ±2.31	20 ±2.31
Butea monosperma	37 ±1.33	44 ±2.31	37.33 ±2.67	38.67 ±3.53	38.67 ±4.81	12 ±2.31
Dalbergia sissoo	34.67 ±3.53	33.4 ±3.53	40 ±2.31	45.33 ±4.81	52 ±2.31	56 ±2.31
Holoptelia integrifolia	2.67 ±0	2.67 ±0	4 ±0	2.67 ±0	10.8 ±0.31	41.67 ±1.33
Leucaena leucocephala	29.33 ±1.33	36 ±2.31	44 ±2.31	46.27 ±2.67	45.33 ±3.53	72 ±2.31
Tamarindus indica	1.33 ±0	1.33 ±0	2.67 ±0	4 ±0	10.67 ±1.33	5.33 ±1.33

Orphan and Heydecker (1968) suggested that soaking injury is caused by deficient oxygen supply to the interior of the soaking seed because as the cavity between the cotyledons is flooded with excess of water. Ghosh et al. (1976) studied that soaking of seed of Pinus patula for 18 hours at room temperature and was most effective for germination. Marunda (1990) reported that H_2SO_4 rendered the seed coat soft causing uniform inflow of

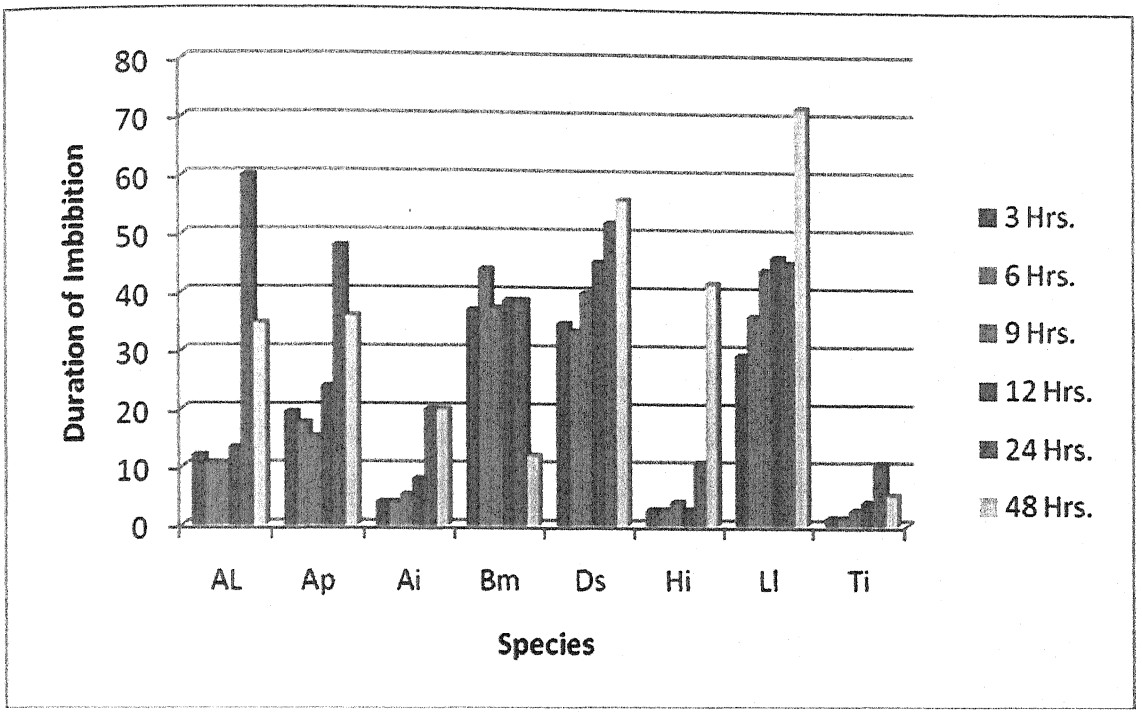


Fig. 6 Comparision between duration of Imbibition at 3, 6, 9 , 12, 24 and 48 Hours of Selected forest species

water resulting activation of embryo and rate of germination. Seeds do not resume physiological activity until they imbibe certain amount of water (Come and Tissaou, 1973).

According to Come and Tissaou (1973) water uptake by seed is a prerequisite of germination. Harper and Benton (1966) assumed that the failure of living seeds to germinate or the delay in the germination is due to insufficient or delayed hydration of the seed. According to Yadav and Mishra (1982), different duration of imbibition affect the germinative capacity of forest tree seeds. Kocchar and Garg (1983) during his experimental studies concluded that continued water stress inhibited seed germination and was observed completely at 5 bar water potential in winged beans. The germination percentage declined as water stress becomes higher.

According to Bewley and Black (1978) on an average, maximum imbibitions during their experiments was observed in *Butea monosperma* and minimum in *D. melanoxylom* up to 3 hrs. while *D. melanoxylom* and *C. fistula* had maximum and minimum imbibitions in 48 hrs. Comparatively seeds with 48 hrs. imbibition period show maximum germination than in control and there appears a positive relationship between imbibition time and germination percentage in all the species except *Butea monosperma* where germination percentage increased up to 6 hrs. of imbibition and followed by a decline which may be due to diminished oxygen supply with accumulation of toxic substances.

Mustafa (1989) and Bahuguna et al. (1987) reported the fact that the seed germination and seedling growth of *Albizzia lebbek* was more pronounced in water as compared to unsoaked seeds. Khasa (1992) has experimented on presuming chemical treatment to hasten germination of *Casuarina equisetifolia*. Berlin (1999) has standardized presowing treatments.

7. Laboratory:

150 seeds / fruits were placed on the tray covered with sterilized and moistened germination paper (supplied by F.R.I. Dehradun as per I.S.T.A. standard) in a germinator at 27 ± 2^{0}C and 90% humidity.

(a.) Emergence time: The emergence time i.e. number of days after which germination commenced and the completion time i.e. number of days needed for

germination of almost all the seeds were found to vary among the species under study (Table 10 and Fig. 9). In most of species, the emergence time ranged between 4 and 9 days. Similarly, the time required for completion of germination varied from 6 to 13 days in almost all the selected forest species. The seeds of *Azadirachta indica* and *Butea monosperma* required minimum time four emergence i.e. 4 and 5 days respectively.

Variation in time (days) required for initiation of germination and its completion in these species may be due to some of the internal factors of seeds like make up of seeds, seed coat permeability to water and oxygen, and external factors like soil, pH, soil texture, varying temperature, amount of CO_2 in soil environment and light intensity. Further appreciable differences in emergence time of seed/fruit of *A. indica and L. leucocephala* are largely due to differences in nature of seed coat. In case of *A. indica,* the seeds appeared to be soft as compared to those of *L. leucocephala*. The latter are perhaps the hardest seeds among all the species of the present study. Though the seeds of *L. leucocephala* are also extremely hard but these could be softened by pretreatment. This hard seed/fruit coat makes itself impermeable to water and oxygen which delays germination process, and consequently longer time period is required for initiation and completion of germination. On the other hand, soft seed body makes them suitable for water and gaseous exchange and results into quick initiation and completion of germination.

(b) Percentage germination: Table 8 shows percentage germination of different forest tree seeds in nursery. The results indicate that percentage germination of seeds varied from species to species under study. On an average, maximum germination (66 %) was found in *Butea monsperma* and minimum was recorded in *Holoptelia integrifolia* (24%). The percentage germination of seeds in nursery was comparatively less than in the germinator (Table 8 and Fig. 7).

Germination percentage of various species under study was found to vary in nursery bed, and these variations can be attributed to the internal factors of seed/fruit and to the external environment. Internal factors include nature of seed coat, chemical composition, amount of stored food, permeability of seed/fruit coat to water and gases

etc. While, the external environment includes the source of seed/fruit collection, topographic variation of habitat, age of parent tree, etc. Moreover in nursery beds the requirements of seeds/fruits for water, temperature, soil texture and pH may vary, which may be responsible for variation in germination percentage.

TABLE 9. MAXIMUM AND MINIMUM TIME REQUIRED FOR INITIATION OF GERMINATION AND PERCENT GERMINATION IN SEED/FRUITS OF SOME IMPORTANT FOREST TREE SPECIES. (VALUES ARE MEAN ± S.E.)

Species	Emergence time (days)		Percent germination
	Minimum	Maximum	
Albizzia lebbeck	5	8	30±2.58
Albizzia procera	5	7	39 ± 3.42
Azadirachta indica	4	6	20 ± 1
Butea monosperma	5	9	166 ± 2.6
Dalbergia sissoo	7	10	30 ± 1.15
Holoptelia integrifolia	7	10	24 ± 2.83
Leucaena leucocephala	7	11	47 ± 5
Tamarindus indica	7	12	23 ± 2.52

During germination studies of these species, it was found that germination percentage significantly depended upon the dimension of seeds/ fruits. For example, the seeds/fruits of high dimension of species *A. indica, B. monosperma and T. indica* showed comparatively better germination then the seeds of small dimension of species *H. integrifolia* and *D. sissoo*. It may be because larger seeds/fruits store greater quantity of food used during the course of germination and development of seedling. While in small seed /fruits, comparatively less food is available to growing embryo for nourishment. Further, the embryo in *H. integrifolia* and *D. sissoo* was either not fully developed or some time totally absent.

The germination percentage of seeds/fruits in some species was more in seed germinator in comparison to nursery, and indicated that the fluctuating condition of light, temperature and water affected the seed germination. Besides, bacteria, fungi, Insects and other arthropods predominant in nursery soil might have played a role in the germination. On the other hand the controlled temperature and moisture conditions of germinator would have facilitated the seed/fruit germination.

Therefore, it appears that the high germination percentage of seeds /fruits of most of the species in seed germinator may be due to favorable temperature and moisture conditions while the fluctuations in moisture and temperature and soil coupled with microbial activities have suppressed the germination percentage in nursery.

TABLE : 10 PERCENT GERMINATION OF SEED / FRUITS OF SOME IMPORTANT FOREST TREE SPECIES IN GERMINATOR (LABORATORY) AND NURSERY BED. (VALUES ARE MEAN ± S.E.)

Species	In germinator	In nursery bed
Albizzia lebbeck	44 ± 2.31	31 ± 2.52
Albizzia procera	42 ± 1.1	39 ± 1.63
Azadirachta indica	21 ± 2.52	20 ± 2.8
Butea monosperma	72 ± 2.5	66.75 ± 2.50
Dalbergia sissoo	45 ± 1.91	39 ± 3.42
Holoptelia integrifolia	27.75 ± 4.5	21 ± 1
Leucaena leucocephala	52 ± 1.15	47 ± 1
Tamarindus indica	26 ± 1.63	34 ± 1.91

8. Temperature:

A perusal of table 9 and figure 8 indicates the effect of temperature on emergence (Number of days after which germination commenced), completion time (Number of days needed for germination of almost all the viable seeds) and the germination percentage of the seeds of all the selected forest species appear to vary. In different

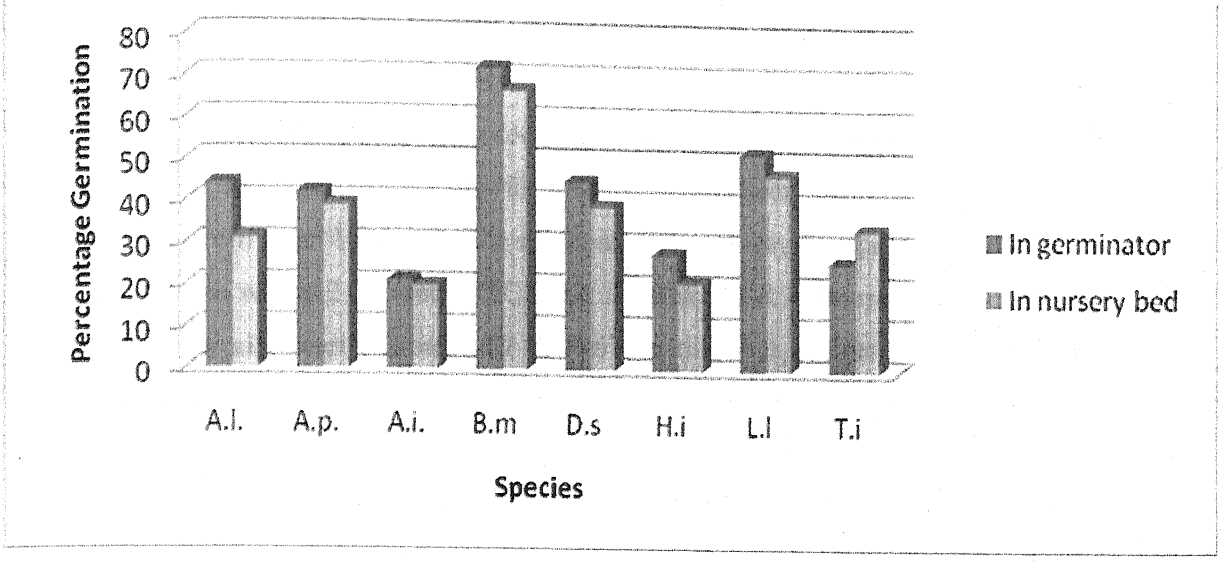


Fig. : 7 (A) Percentage germination of seeds of selected tree species in germinator (Laboratory) and nursery bed

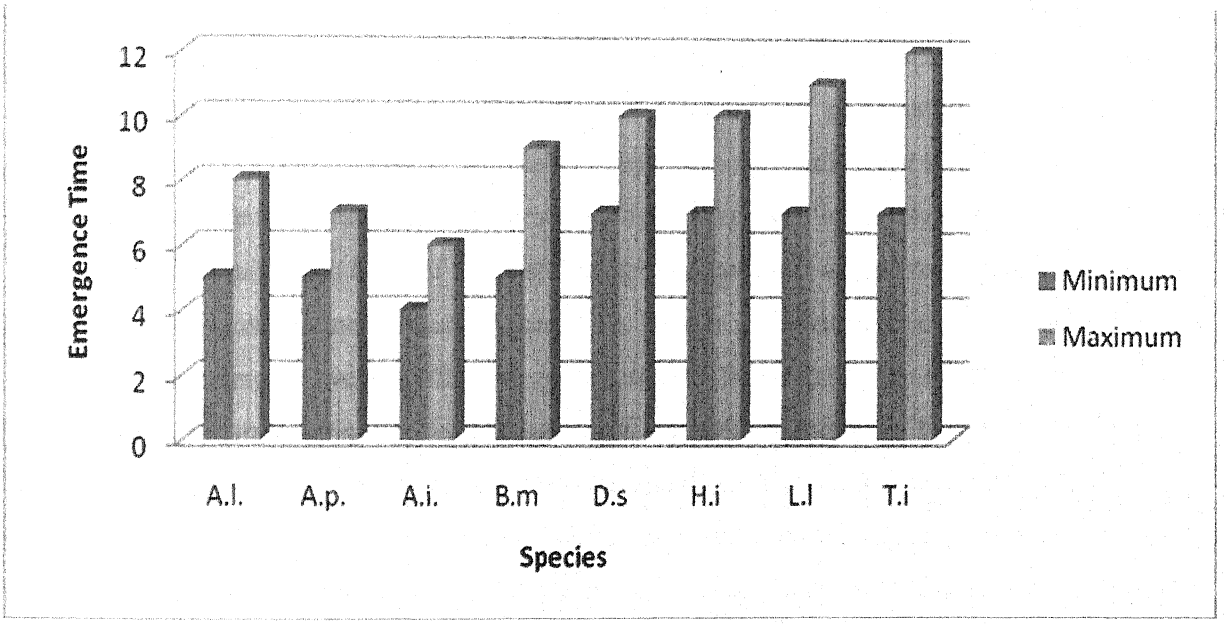


Fig. : 7 (B) Minimum and Maximum time required for the initiation of germination and percentage germination of seeds of some common forest tree species.

regimes of temperatures the emergence time ranged between 3 to 7 days, the minimum time (3 days) was taken for this process at 30^0 C for the *B. monosperma* and at 25^0 C in *A. lebbeck,* respectively. Similarly the time required for completion of germination is also variable from 4 to 10 days. The minimum time (3 days) required for completion of germination was at 25^0 C and 30^0 C for *A. lebbeck* and *B. monosperma*. The germination percentage also varies from 2.67 to 6.67 at different temperatures. The maximum percentage of germination was found at 25^0 C and minimum at 35^0 C temperature. The germination percentage rises with rise in temperature up to 30^0 C and a steep decline in it was observed with further rise in temperature from 30^0 C to 35^0 C. The days taken for emergence and completion of germination showed a trend of decrease with increasing temperature up to 30^0 C and beyond 30^0 C, the number of days require for germination increased. The optimum temperature for germination of the seeds of these species was found to be 30^0 C. No seeds could germinate below 20^0 C and above 35^0 C temperatures. These differences in germination behavior of seeds at different temperature may be due to the sensitivity of various physiological processes of germination and at 30^0 C temperature happen to operate invariably at optimum rate in different species.

Since temperature and substratum plays a very significant role during the process of seed germination. Seed of some species germinate better on constant temperature and others on alternate temperature (Anon, 1993, Bonner 1972 and Kumar and Tokyo, 1996). The experiments were performed to investigate the importance of these factors to determine the optimum temperature and suitable substratum to influence better germination of seeds of *Azadirachta indica*. The dried seeds was stored at room temperature in air tight cotton bags. Germination tests were conducted in laboratory, as per the procedure recommended by international seed testing association (Anon, 1993). The mean daily germination (MDG) was calculated to determine the rate of germination according to the procedure recommended by Tompsett (1985).

The germination percent was greatly influenced by temperature. Gupta and Kumar (1977) studied the effect of temperature and moisture on germination of *Dendrocalamus strictus* and reported that 30^0 C temperature and 50-75% moisture level was optimum for better germination. In a separate study, they also reported that in

Dalbergia sissoo seeds placed at room temperature of 20^0 C between germination (Towel) paper showed better germination (Kumar and Bhatnagar, 1976).

Thakur et al. (2002), observed a very high percentage germination in five species of medicinal plant in the temperature range of 25 to 30^0 C, they further noted fast rate of germination as it takes only few days to initiate the process in temperature range of 20^0 C to 25^0 C It can be observed that seeds show less germination percentage below 20^0 C and above 35^0 C. Thus it can be inferred that 20^0 C to 35^0 C was most congenial for germination.

The results of study on temperature selection to seed germination are very much similar to the study by Tiwari (1994), Chaudhary (1994), Tripathi (1995) and Jain (1996). Chaturvedi (1998) also studied the temperature effect on selected forest tree species of tropical dry deciduous forest of central India and found similar results Anju et al. (2000) studied the effect of different temperature and substrate on the germination of Kadam *(Anthocephalus chinensis)*. Similar results have been found by Nikhil et al. (2001) on seed germination in certain seed species.

Under unsuitable temperature, the seeds of any species fail to germinate or they show poor germination. Most of the previous report on seed germination by Wright (1931), Nizuma (1936), Quantivan (1966), Ellens (1967), Datta (1968), Tissaouri (1973), Maguire (1973) described merely the effect of low, high or optimum temperature on seed germination of some species. Thompson (1974) in his study on seed germination in four species has observed beneficial effects of fluctuating temperature on them. Kumar and Bhatnagar (1976) studied the effect of temperature and substratum on seed germination of *Dalbergia sissoo* and concluded that the seed placed at a temperature of 30° C in between germination paper shown better germination. Gupta and Kumar (1977) reported the 30° C is the ideal temperature for the germination of *Dendrocalamus strictus* while, Kumar (1980) found increase in rate and percentage germination in *Pinus contorta* with rise in temperature of 10 to 20° and 20-30° C. Santra et al. (1981) reported low temperature to be favourable for *pilosa* seeds.

TABLE 11: EFFECT OF DIFFERENT TEMPERATURES ON GERMINATION PERCENTAGE OF SEEDS OF DIFFERENT SPECIES

Species	20^0 C			25^0 C			30^0 C			35^0 C		
	B	C	Germ. %	B	C	Germ. %	B	C	Germ. %	B	C	Germ. %
Albizzia lebbeck	5	8	45.24	3	5	65.20	4	7	60.14	5	9	49.37
Albizzia procera	4	7	27.94	4	6	39.48	5	8	35.42	5	9	22.41
Azadirachta indica	5	8	18.44	4	6	21.42	4	7	18.02	5	8	11.94
Butea monosperma	5	7	42.87	3	5	58.08	4	5	52.17	5	6	45.44
Dalbergia sissoo	5	9	54.77	5	8	76.52	6	9	74	7	9	66.29
Holoptelia integrifolia	6	8	48.42	5	8	66.00	5	7	69	6	9	53.42
Leucaena leucocephala	5	6	51.82	4	8	73.20	5	9	71.43	6	10	60.82
Tamarindus indica	5	8	32.84	5	7	42.94	4	7	44.97	4	6	29.44

* B = BEGINNING OF GERMINATION

* C = COMPLETION OF GERMINATION.

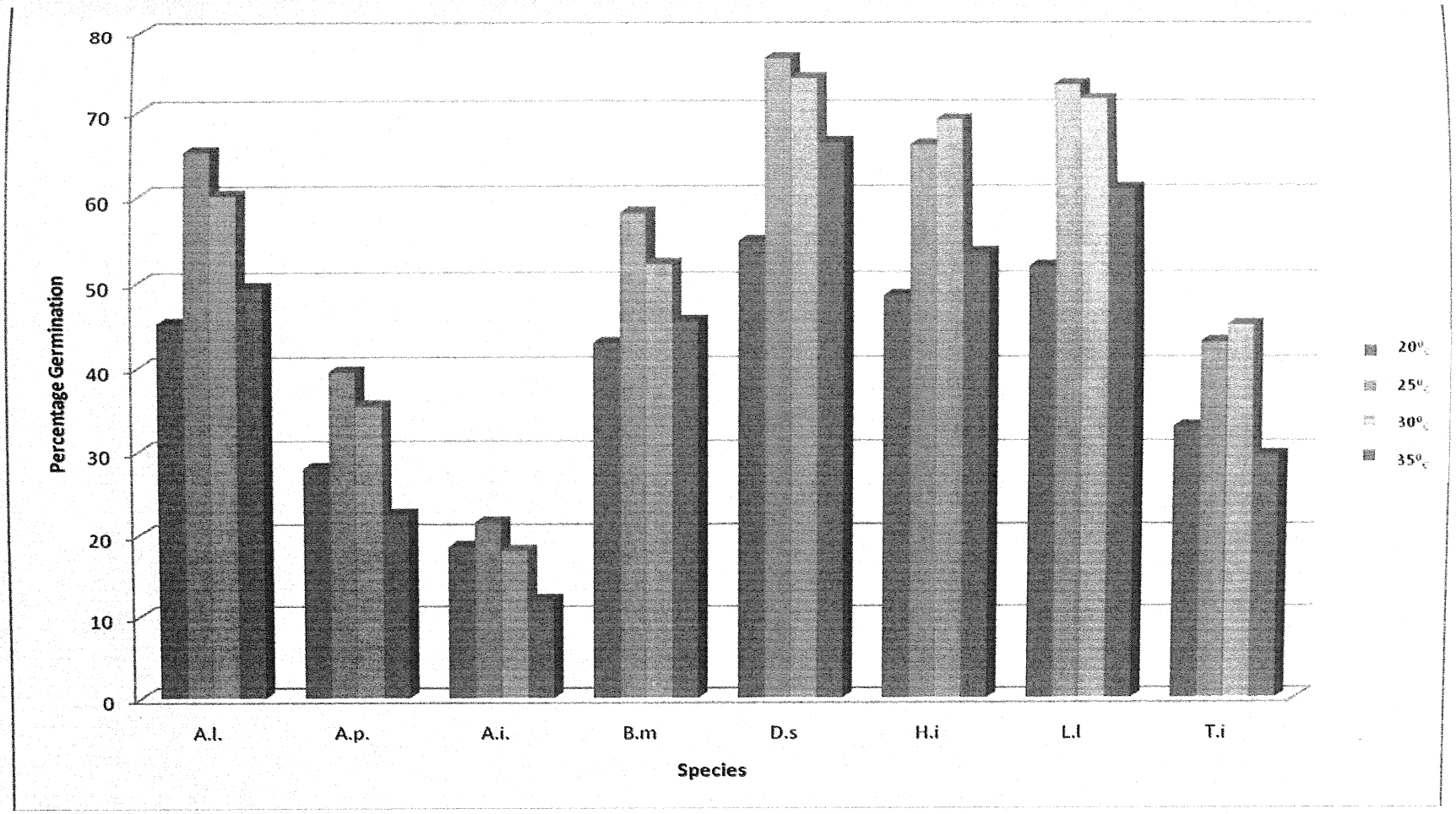


Fig. : 8 Comparison of germination percentage at different temperatures in selected forest tree species *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

Part – II

Seeding Growth Studies :

Beside seed germination, the studies on growth behaviour of seedlings at early stages of life of any plant species is a very important aspect, as it has great bearing on establishment and further success of any programme of plantation. These studies include the understanding of the different requirement of seedlings to obtain optimum growth and production in future. These may be matching of a species with suitable soil media, sowing depth to the seed of particular species so as to obtain prompt emergence and successful completion of germination, suitable moisture regime, light intensity and treatment of growth hormones if required. In present study it is planned to investigate the growth dynamics of seedling of selected species in relation to different factors, at early stages of life, so as to achieve better and healthy seedlings at nursery level.

The result of effect of three different light intensities on seedling growth is given in table no. 12. The seedling growth under different lights intensities has also been shown in Figure no. 9-10.

A persual of data in table no. 12 and figure 9 indicate that an average maximum length of root (177.5 cm) and shoot (222 cm) was obtained in 100 percent light in case of *Leucaena leucocephala* while minimum growth was observed in *Holoptelia integrifolia* in 20 percent light condition followed by *Albizzia lebbeck* with almost no growth.

The fresh weight of root (95.75 gm) and shoot (366.25 gm) fresh weight was reported maximum in *Leucaena leucocephala* followed by *Albizzia procera* (19.75 gmand 33.15 gm) *Dalbergia sissoo* (17.75 gm and 32.25 gm) *Azadirachta indica* (9.25 gm and 31.25 gm), and *Tamarindus indica* (6 gm and 21.5 gm), respectively. The minimum fresh weight of root and shoot was obtained in case of *Holoptelia integrifolia* (1.5 gm and 9.5 gm) and *Albizzia lebbek* (5.0 gm and 9.25 gm).

The root and shoot dry weight also followed similar pattern. The ratio of shoot/root weight shows a different trend; as it was miximum in 100 percent light and decreases gradually in 45 to 20 percent light respectively in almost all the species. The root/shoot ratio shows an increasing trend gradually in 45 < 100 < 20 percent light condition. The root/shoot ratio shows an increasing trend gradually in 45 < 100 < 20 percent light condition. The average number of branches was observed higher (59.5) in case of *Leucaena leucocephala* and lowest (1.5) in *Dalbergia sissoo* in 20 percent light condition.

Table no. 12 Effect of different Light conditions on (various growth parameters)of one year old seeding of *Albizzia lebbeck (Al) Albizia procera(Ap.)Azadirachta indica (Ai), Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll)* and *Tamarindus indica (Ti)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Sunlight (I)								Semi Shade(II)								Diffused light (III)							
	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti
Root Length(cm)	52 ±3.77	24 ±0.57	42 ±1.14	38 ±0.70	50 ±0.68	33.5 ±0.44	117.5 ±2.5	47 ±0.31	32.4 ±0.57	42.5 ± .63	20 ±0.70	59 ±0.35	36 ±3.05	39 ±0.63	82.5 ±4.51	26.5 ±0.88	14.1 ±0.70	12 ±1.14	12 ±1.41	5.5 ±0.27	10.2 ±0.6	11 ±0.31	26.5 ±1.40	5.8 ±0.10
Shoot Length(cm)	66 ±3.70	46 ±0.35	91 ±4.53	33 ±0.35	92.5 ±2.23	35.5 ±0.47	222 ±2.95	86 ±0.41	36 ±0.70	55.5 ±1.41	32.5 ±2.78	51 ±0.35	44..5 ±0.082	47 ±0.31	167 ±6.16	45 ±1.1	9.8 ±0.57	9 ±1.06	20.5 ±0.77	9.2 ±0.14	12.25 ±0.082	15.1 ±0.40	61.5 ±3.97	13.5 ±0.51
Plant Length(cm)	118 ±2.14	70 ±0.89	133 ±4.54	71 ±1.06	142.5 ±2.89	69 ±0.89	339 ±0.48	133 ±1.70	70 ±0.70	98 ±.77	52.5 ±3.32	110 ±0.70	8.05 ±4.04	84 ±1.91	249.5 ±4.20	71.5 ±1.98	23.9 ±0.35	22 ±1.61	32.5 ±0.70	14.7 ±0.38	22.45 ±0.14	26.1 ±0.73	87.6 ±5.60	19.3 ±0.64
No.of Branches	13 ±0.35	6 ±0.28	25 ±0.35	5.6 ±0.54	25.5 ±0.82	16.5 ±0.44	59.5 ±1.56	37.5 ±0.5	6 ±0.70	13.8 ±.33	13 ±1	5 ±0.35	12.5 ±0.082	17.5 ±0.77	37.5 ±1.07	19 ±0.31	3 ±0.35	4 ±.55	8 ±0.08	1.5 ±0.18	1.5 ±0.17	11.2 ±1.41	18 ±0.35	5.5 ±0.18
Shoot/Root ratio	1.27 ±0.01	1.92 ±0.37	2.15 ±0.05	0.86 ±0.005	1.84 ±0.63	1.06 ±0.16	1.89 ±0.01	1.82 ±0.01	1.105 ±0.01	1.35 ±1.44	1.59 ±0.08	0.86 ±0	1.29 ±0.08	1.795 ±1.11	2.039 ±0.25	1.7 ±0.017	1.8 ±0.57	0.75 ±.17	1.66 ±0.36	1.68 ±0.05	1.2 ±0	1.35 ±0.01	2.31 ±0.032	2.31 ±0.047
Root fresh wt.(g.)	5 ±0.57	13 ±1.90	9.28 ±0.77	13.75 ±1.49	17.75 ±0.38	1.0 ±0.28	95.75 ±0.37	6 ±0.57	2 ±0.17	19.75 ±.33	2.5 ±0.36	25.15 ±0.57	3.6 ±0.12	1.5 ±0.31	73 ±3.72	9.88 ±2.18	1.5 ±0.08	10.4 ±.35	2 ±1.13	18.5 ±0.61	1.12 ±0.12	0.37 ±0.04	13.8 ±0.55	2.8 ±0.14
Shoot fresh wt(g.)	9.25 ±0.08	16.85 ±0.11	31.25 ±0.27	8.75 ±0.25	32.25 ±0.57	2.25 ±0.30	366.25 ±0.37	21.5 ±1.04	3.25 ±0.28	33.15 ±.27	6.75 ±1.13	11.5 ±1.41	26.9 ±0.050	9.5 ±0.63	171.4 ±1.53	7.35 ±1.03	2.75 ±0.01	14.6 ±.38	4.2 ±0.45	2.8 ±0.14	6.2 ±0.20	1.75 ±0.25	47.7 ±4.45	4 ±0.27
Root Dry wt.(g.)	2.27 ±0.31	6.2 ±0.40	4.27 ±0.17	6.75 ±0.78	10.75 ±0.03	0.50 ±0.12	50.7 ±0.95	3.85 ±0.12	1 ±0.09	9.8 ±.77	0.99 ±0.08	18.35 ±0.58	3.27 ±0.07	0.80 ±0.22	31.1 ±3.31	1.18 ±0.14	0.75 ±0.25	5.2 ±.18	0.99 ±1.90	9.3 ±0.38	0.5 ±0.08	0.21 ±0.77	6.22 ±0.38	1.45 ±0.08
Shoot Dry wt(g.)	5.75 ±0.25	8.3 ±0.21	20.6 ±0.75	4.25 ±0.08	20 ±0.55	1.12 ±0.12	182 ±9.25	10 ±0.57	1.72 ±0.16	18.45 ±.05	4.1 ±0.95	5.3 ±0.63	17.17 ±0.32	4.3 ±0.32	79.3 ±2.37	4.3 ±0.71	1.92 ±1.	7.3 ±.57	2.9 ±0.11	1.4 ±0.07	2.85 ±0.18	3.4 ±1.41	28.3 ±2.35	2.1 ±011
Moisture %	43.71 ±1.53	47.74 ±0.77	44.87 ±0.92	51.14 ±0.09	39.42 ±0.38	50.5 ±0.18	49.61 ±0.32	49.63 ±0.94	48.19 ±0.66	46.59 ±.10	39.49 ±1.90	35.47 ±0.21	45.66 ±059	53.63 ±0.59	45.82 ±0.11	45.03 ±0.66	46.92± 1.53	48.94 ±.94	41.42± 0.35	45.68 ±1.34	54.23 ±1.69	51.42 ±0.44	43.86± 0.17	47.79 ±0.40
R/S dry wt.Ratio	2.53 ±0.27	1.34 ±0.16	4.83 ±0.02	0.62 ±0.08	1.86 ±0.03	3.2 ±0.07	3.59 ±0.11	2.49 ±0.06	1.67 ±0.01	1.79 .52	4.04 ±0.11	0.28 ±0.02	3.43 ±0.40	2.25 ±0.52	2.54 ±0.21	3.51 ±0.11	1.17 ±0.27	1.08 ±.32	2.92 ±0.77	0.145 ±0.01	9.04 ±0.05	0.80 ±0.16	4.49 ±0.10	1.44 ±0.07

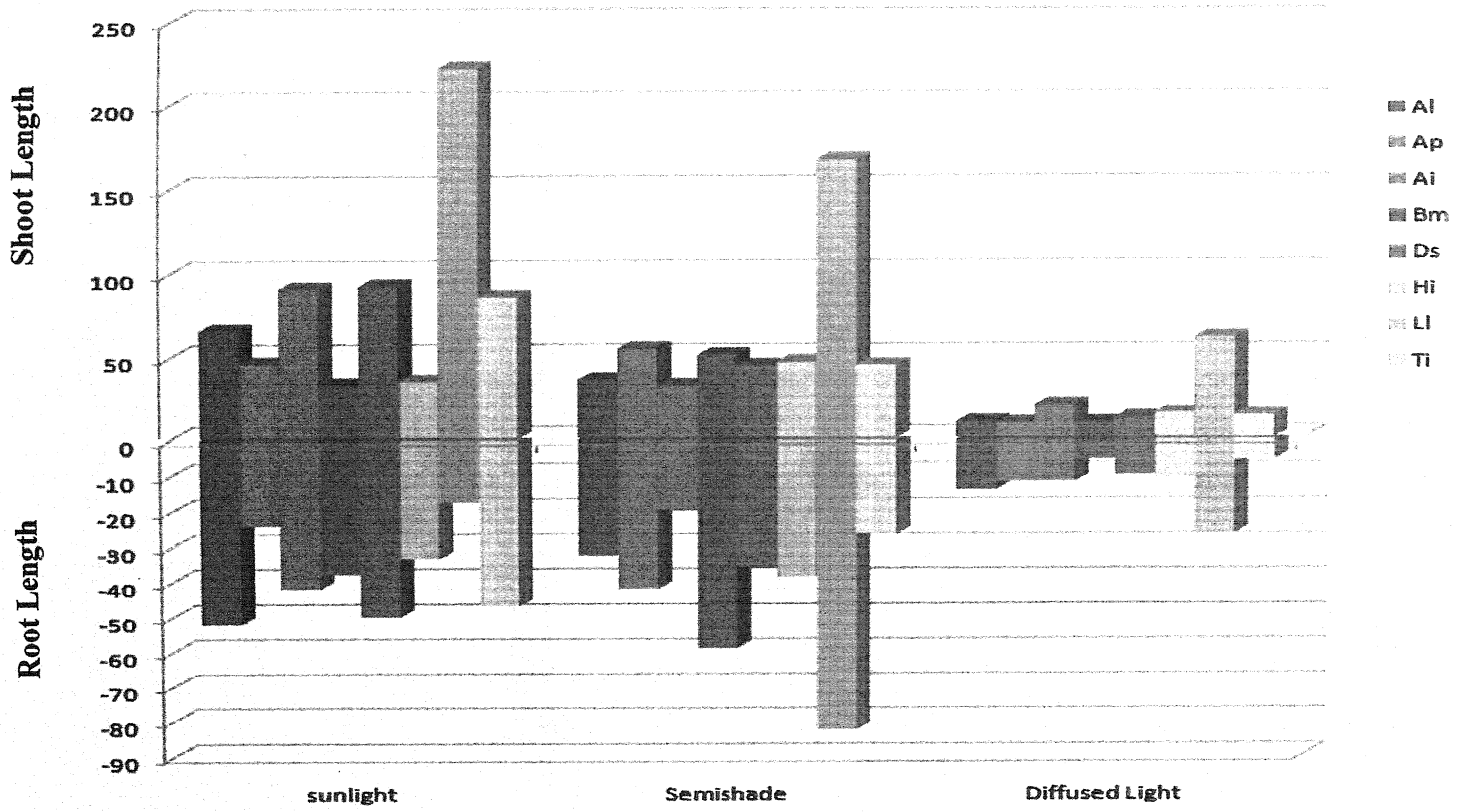


Fig. : 9 Effect of differentLight conditions on Root & Shoot length of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

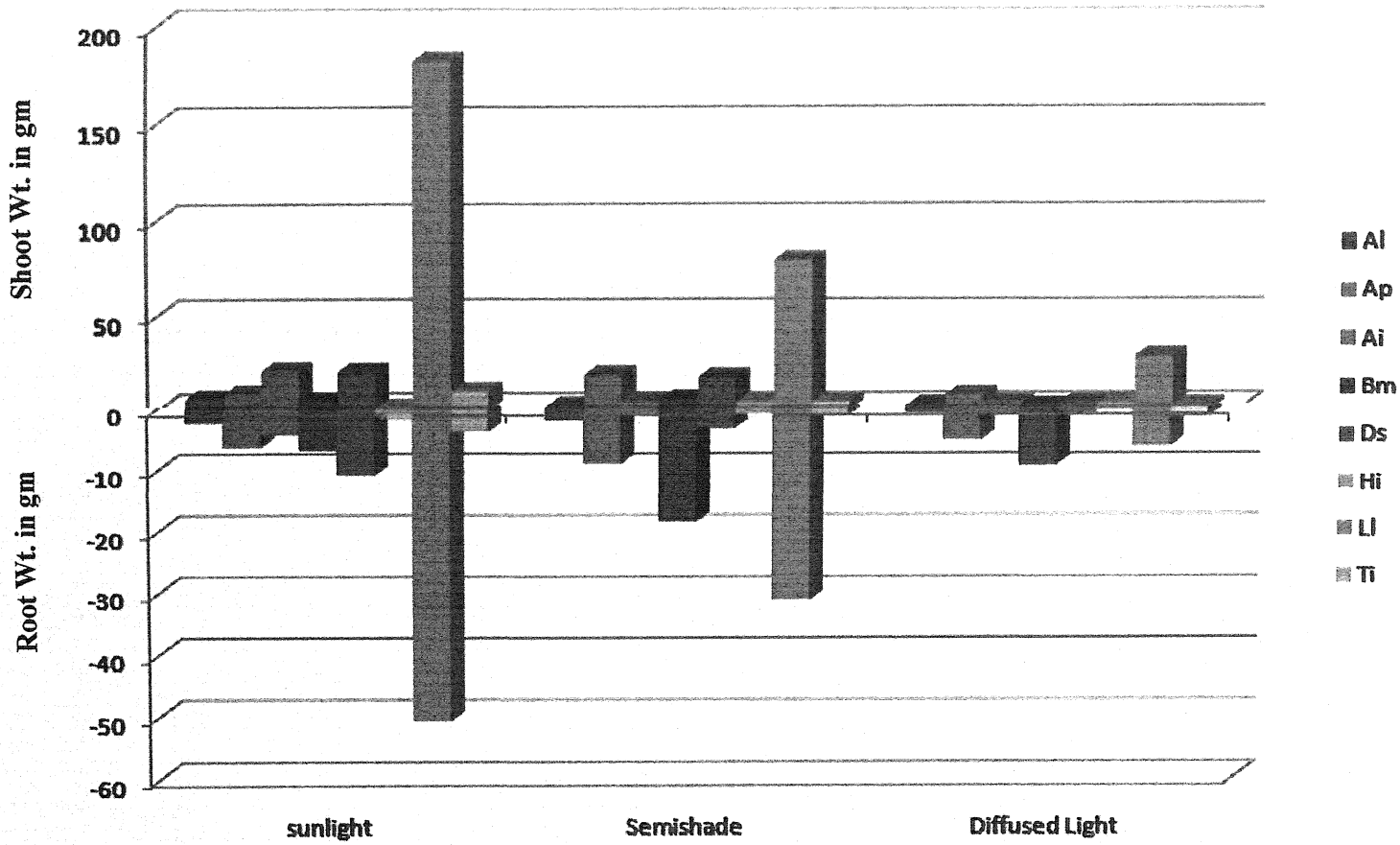


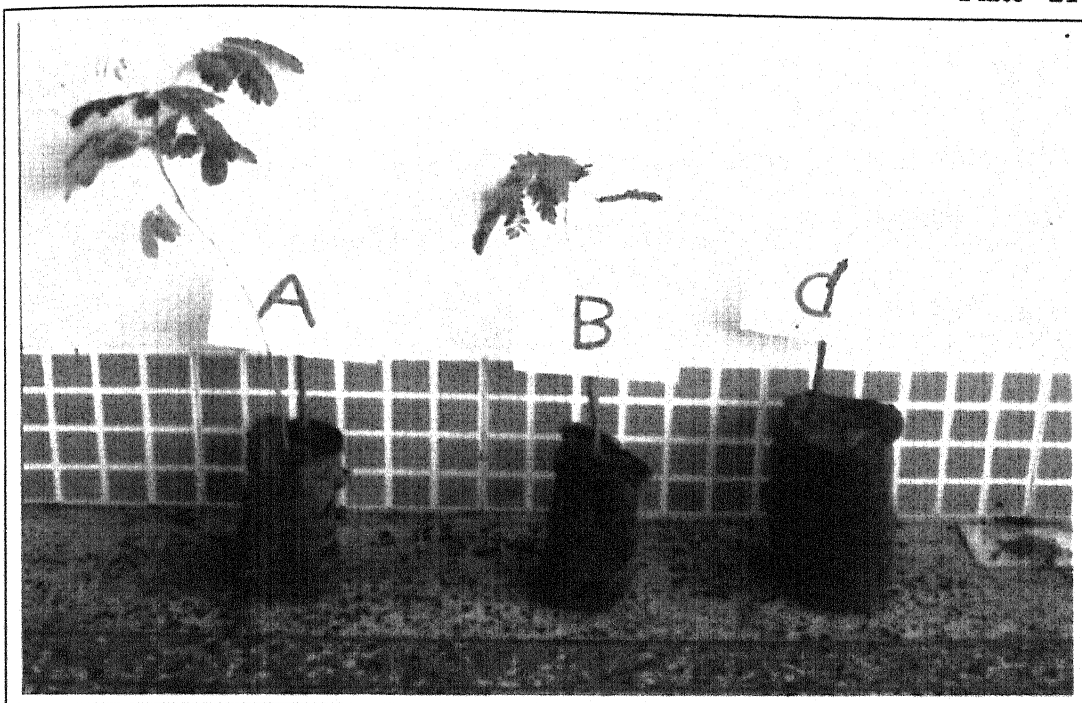
Fig. : 10 Effect of different Light conditions on Root & Shoot Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

The average growth remained higher under sunlight condition followed by semishade and diffused light condition in all the species trialed. This growth shows a decreasing trend from *Leucaena leucocephala, Dalbergia sissoo, Azadirachta indica, Butea monosperma* and *Albizzia lebbeck* species. The minimum growth was obtained in *Holoptelia integrifolia* and *Tamarindus indica.* The later germinates quickly but its growth is slow as compared to other forest species.

The minimum dry weight and length of root and shoot was found in 20% light. This may be attributed indirectly to inadequate nutrition. The absolute light condition might have an adverse effect on the growth of seedlings of *Butea monosperma* and *Holoptelia integrifolia* due to increased temperature and decreased moisture in soil.

The growth of seedling is influenced by light intensity and light quality .Sun is the universal source of energy which is fixed by them in the form of chemical energy by photosynthetic carbon assimilation for use in various life processes. During the early phase of life, many plant species are shade loving or light demanding. The above results of present finding may be supported by earlier studies made by Chaturvedi and Bajpai (1999) who observe nearly same effect of light condition on the seedling of *Bridelia retusa, Lagerstromia parviflora and H. antidysenterica. F*urther Tiwari et al. (2000)and Borthwick (1954) further observe the better growth of seedling of Lettuce in semi shade conditions.

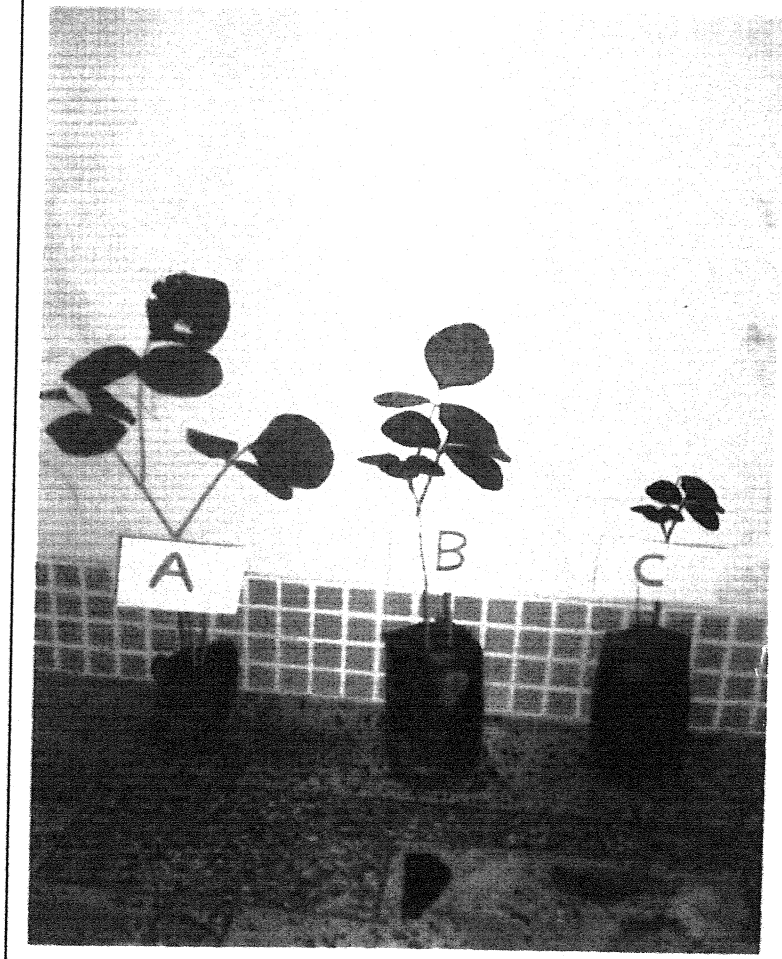
Blackman and Wilson (1951 and Blackman et. al (1955) studied growth of herbaceous plants and concluded light as a limiting factor. Shirley (1929) studied the influence of light intensity and quality on the growth of plants. Loach (1957) has worked out tolerance of light intensity in tree seedlings. Robert (1971) found that in Red Oak (*Quercus rubra* L.) the tallest seedlings grow in 30% light. Pathak et al. (1983) during the study of *Leucaena leucocephala* Lam. found that the seedlings raised under 45% light conditions showed better height and total dry matter. Many plant species are shade loving or light demanding during their early phase of life. The researches on this important aspect have been done by many investigators namely Martin, (1968) Meher-Honji (1973), Williams (1970), Mishra and Benergi (1995), Nanhorya and Srivastava (1999) and Leyton et al. (1957).



Effect of different light conditions on one year old seedling of *Albizzia lebbeck*

Effect of different light conditions on one year old seedling of *Albizzia procera*

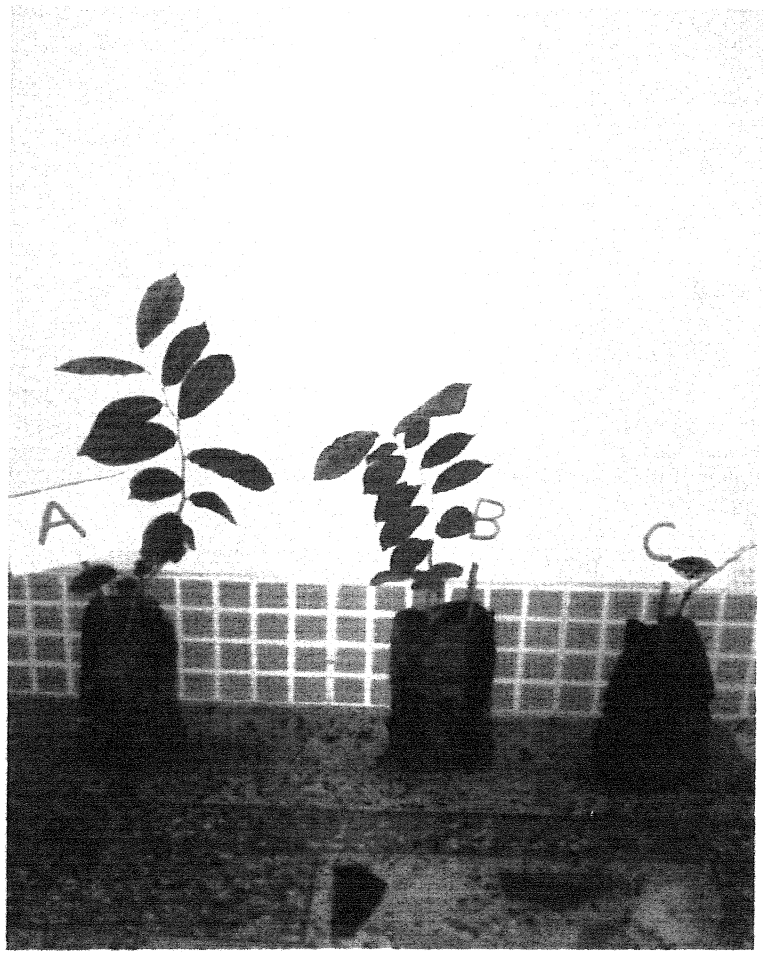
Effect of different light conditions on one year old seedling of *Azadirachta indica*



Effect of different light conditions on one year old seedling of *Butea monosperma*

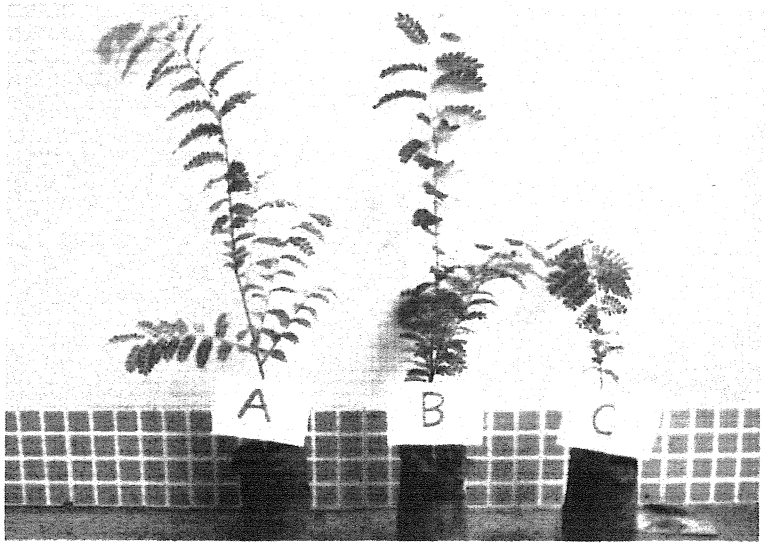
Plate - 23

Effect of different light conditions on one year old seedling of *Dalbergia sissoo*



Effect of different light conditions on one year old seedling of *Holoptelia integrifolia*

Effect of different light conditions on one year old seedling of *Leucaena leucocephala*



Effect of different light conditions on one year old seedling of *Tamarindus indica*

The absolute light condition may have an injurious effect on the growth of seedlings due to increased temperature and decreased moisture in the soil. The present findings are in agreement with the results of Pathak et al. (1983) as such they found that the seedlings of *Leucaena leucocephala* grow under the tree canopy (45% light) showed better height and greater dry matter. Similarly, Robert (1971) also found the tallest seedlings of *Quercus Rubra* L in semi shady condition, except the dry weight of seedlings was comparatively lesser than that of absolute light. Many workers like Troup (1921); Bhargava (1951), Mathur (1956), have indicated essentiality of partial or lateral shade in the earlier stages of seedlings of certain species which protect them from drought. While others species which showed better growth in full sunlight may be light demander during their early phase of growth. Irrigation is the most important aspect, which fulfills the requirement of water in plant life. Moisture appears to the most important functional constituent of biological cell affecting almost all the vital physiological process. It is indirectly related to the cell division and various other functioning processes. In soil a balance content of water allows a suitable level of soil air. It indirectly controls the growth performance of seedlings

An examination of data (Table no 13 and Fig. 11) on the effect of irrigation conditions on seedling growth indicate that, on an average, the maximum root length in decreasing order was found in *Leucaena leucocephala* (108 cm), *Dalbergia sissoo* (62.5 cm), *Albizzia lebbeck* (61cm), *Butea monosperma* (61 cm) *Albizzia procera* (56 cm), *Tamarindus indica* (42.5 cm) and *Azadirachta indica* (42 cm). Minimum root length was observed in *Holoptelia integrifolia* (22 cm) both in and I and II conditions of irrigation. All the species except *Leucaena leucocephala* thrives best in category II while *Leucaena leucocephala* requires best irrigation through category III.

Again shoot growth was maximum in *Leucaena leucocephala* (297 cm) seedlings of irrigation category III and a decreasing trend of growth was observed in *Albizzia lebbeck* (114 cm), *Azadirachta indica* (91.5 cm,) and *Dalbergia sissoo* (83.5 cm) in II category of irrigation while seedlings of *Tamarindus indica* (84.5cm) grew well in III category and *Albizzia procera* (72 cm,) to those of I category. Minimum shoot growth was observed in *Butea monosperma* (37.5 cm, category II) and *Holoptelia integrifolia* (31 cm) in II category of irrigation.

Table no. 13 Effect of different irrigation conditions on (various growth parameters)of one year old seeding of *Albizzia lebbeck(Al)Albizia procera(Ap.)Azadirachta indica (Ai), Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll)* and *Tamarindus indica (Ti)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	**Daily (1)**								**Alternately(II)**								**Twice /Weekly III**							
	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti	Al	Ap	Ai	Bm	Ds	Hi	Ll	Ti
Root Length(cm)	41 ±1.84	47.5 ±2.58	33.5 ±4.03	54 ±2.13	46 ±1.26	20 ±.63	90 ±.63	42 ±.70	61 ±0.31	50.5 ±1.91	42 ±1.06	61 ±2.13	54.5 ±2.30	21 ±0.31	107 ±0.2	67 ±2.33	40 ±1.84	54.5 ±0.5	28.5 ±0.5	56.6 ±1.20	62.5 ±6.81	220 ±.63	108 ±1.18	84.5 ±4.46
Shoot Length(cm)	52.5 ±2.69	64.5 ±0.92	53 ±4.67	3.5 ±3.26	58.5 ±1.14	27 ±.96	197.5 ±1.92	69.5 ±1.62	114.5± 3.74	72 ±0	91.5 ±4.93	37.5 ±0.92	83.5 ±3.18	31 ±0.31	217 ±0.42	108.5 ±2.47	65 ±1.84	72.5 ±3.0	67 ±1.77	37.5 ±2.61	78.5 ±5.86	30 ±0.63	246 ±2.02	127 ±2.48
Plant Length(cm)	93.5 ±4.70	112 ±3.28	86.5 ±9.36	89 ±5.17	104.5 ±2.55	46 ±1.69	287.5 ±2.33	116.5 ±.05	175.5± 1.18	122.5± 1.98	133.5± 5.94	98.5 ±4.41	138 ±5.25	52 ±2	324 ±1.26	174.5 ±2.41	105 ±3.53	122 ±1.7	95.5 ±2.29	94 ±3.96	14 ±7.88	52 ±1.26	354 ±3.2	211.5 ±0.17
No.of Branches	13 ±0.31	10.5 ±0.5	15 ±1.06	9.85 ±1.42	30 ±1.38	14 ±.31	57.5 ±.88	26.5 ±0.02	18±0.6 7	12.5±. 88	24 ±.70	7.2 ±.76	30 ±0.63	13 ±0.31	56 ±1.84	34.5 ±2.41	20.5 ±0.5	18± 0.5	17.5 ±0.88	5 ±0.35	20.5 ±0.16	16 ±0.63	6.2 ±0.28	28.4 ±0.35
Shoot/Root ratio	1.27 ±.008	1.38 ±.0.59	1.63 ±0.06	.65 ±0.27	1.38 ±0.74	1.34 ±1.11	3.33 ±1.18	1.53 ±.057	1.87 ±0.04	1.44±0 .05	2.165± 5.8	0.62 ±0.02	1.53 ±0.16	1.45 ±0.01	2.02 ±2.99	1.65 ±5.94	1.63 ±0.02	1.32±0 .043	2.34 ±0.02	0.65 ±0.03	1.23 ±0.58	1.36 ±0.20	2.28 ±0.29	2.04 ±0.67
Root fresh wt.(g.)	12.6 ±0.90	5.5 ±.5	2.5 ±0.35	52.5 ±9.24	3.5 ±.16	.50 ±.08	164.75 ±1.14	4 ±.078	60 ±1.41	28.25± 3.3.	9.25 ±.74	27.25 ±0.60	5.2 ±0.85	0.5 ±0	45.3 ±3.19	14.75 ±0.60	8.75 ±0.97	9.25±0 .64	6 ±0.53	21.45 ±0.36	15.5 ±2.43	1 ±0.15	71.4 ±0.46	14.5 ±0.26
Shoot fresh wt(g.)	23.9 ±1.48	8.75 ±.81	8.55 ±0.37	43 ±6.58	13 ±.47	2 ± .10	694.5 ±2.65	7.75 ±1.37	135.75 ±5.97	48 ±1.99	31.5 ±0.35	31.95 ±3.60	44.5 ±0.16	2 ±0.10	182.5 ±3.27	45 ±6.19	15.25 ±0.43	13.5±1 .77	17.6 ±1.42	25.8 ±0.86	32 ±4.57	3 ±0.15	464 ±0.53	19 ±0.85
Root Dry wt.(g.)	6.9 ±.22	2.75 ±.46	1.12 ±0.13	26.5 ±4.17	3 ±.57	.34 ±0.05	89.2 ±1.13	13.95 ±.51	38.5 ±2.78	15.95± 3.02	5.5 ±0.70	13 ±1.55	7.14 ±0.52	0.12 ±0	27.52 ±2.57	19.75 ±6.90	5 ±0.31	5.11±0 .44	2.75 ±0.25	14.1 ±0.97	8.51 ±0.62	0.50 ±0.08	42.85 ±2.62	7 ±0.093
Shoot Dry wt(g.)	12.9 ±1.7	41 ±.57	3.75 ±0.94	22.32 ±3.60	7.75 ±.78	1 ±0.09	309 ±2.05	3.69 ±0.73	72.75 ±1.07	26.37± 4.52	16.25± 1.27	11.9 ±0.54	23.3 ±0.54	1 ±0.08	69.8 ±3.20	26.3 ±0.73	7.5 ±0.31	7.71 ±0.83	7.5 ±0.71	13.5 ±1.13	17.37 ±3.31	1.72 ±0.16	24.5 ±2.40	10.3 ±0.73
Moisture %	45.75 2.50	52.63 ±2.77	55.92± 0.42	48.87 ±0.32	52.84 ±.50	52.4 ±.59	53.65 ±0.30	51.57 ±0.44	34.82 ±4.8	47.28± 2.49	45.96± 3.86	51.11 ±0.02	37.87 ±1.84	55.20 ±0.40	57.27 ±2.22	35.48 ±2.61	46.80 ±0.19	42.53± 0.68	56.9 ±0.54	41.58 ±0.15	45.53 ±2.07	44.50 ±1.57	47.45 ±0.40	47.09 ±0.94
R/S dry wt.Ratio	1.87 ±0.03	1.45 ±0.05	3.16 ±0.17	.84 ±0	2.58 ±.25	9.33 ±1.98	3.46 ±0.02	2.27 ±0.07	1.88 ±0.12	1.7±0. 31	2.95 ±0.17	0.73 ±0.03	3.58 ±.40	8.33 ±0.76	2.56 ±0.04	2.27 ±0.02	1.5 ±..034	1.46±0 .033	2.73 ±.007	0.99 ±0.06	2.045 ±.005	3.96 ±0.34	5.85 ±0.29	5.15 ±0.15

Root and shoot fresh weight was observed in decreasing order as follows:

Leucaena leucocephala > *Butea monosperma* >
(164.7 gm, category III) (60.2 gm, categoryII)

Albizzia lebbeck > *Albizzia procera* > *Dalbergia sissoo* >
(5.02 gm, category II) (28.25 gm, category II) (15.5 gm, category III)

Tamarindus indica > Azadirachta *indica* > *Holoptelia integrifolia*
(14.75 gm, category II) (9.25 gm, category II) (1 gm, category II)

Shoot fresh weight in decreasing order was as follows:

Leucaena leucocephala > *Albizzia lebbek* > *Albizzia procera*
(694 gm, category I) (135.75 gm, categoryII) (48 gm, category II)

Dalbergia sissoo > *Tamarindus indica* > *Butea monosperma*>
(45.5 gm, category III) (45 gm, category II) (43 gm, category I)

Azadirachta indica > *Holoptelia integrifolia*
(31.5, gm, category II) (21, gm, category III)

Number of branches was found maximum in *Leucaena leuocephala* (62), *Albizzia procera* (128) and *Tamarindus indica* (127).

An examination of results reveal that maximum root -shoot length was found in irrigation category II and decreasing order was followed by category I and III while shoot length of seedlings was found same in both (I and II) category of irrigation, except III category where it was minimum (30.00 cm.) . Percent moisture content in root was higher in I and II category as compared to III one. In shoot, percentage of moisture content followed the trend of decrease from I > III >II category of irrigation. The dry

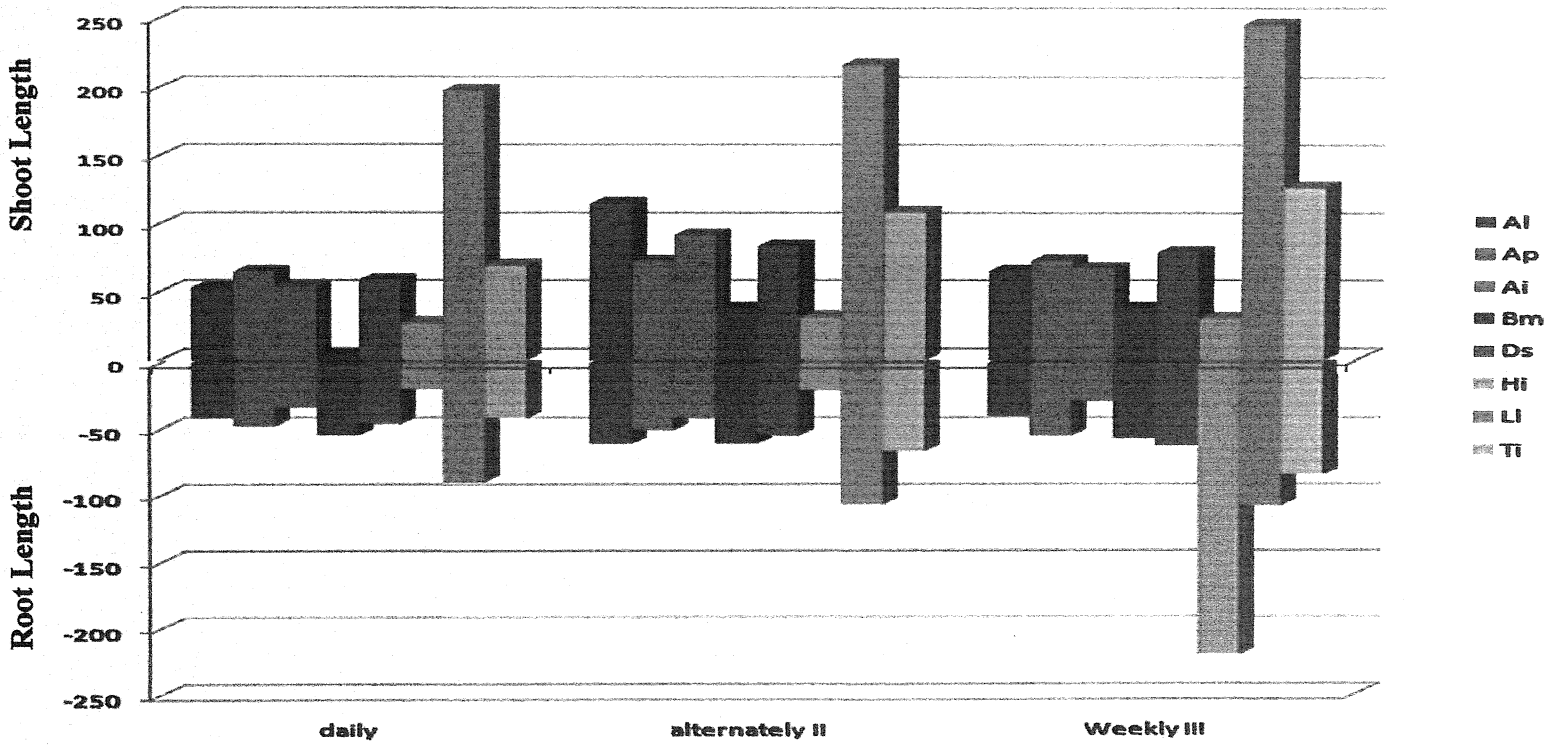


Fig. : 11 Effect of different irrigation conditions on Root & Shoot length of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

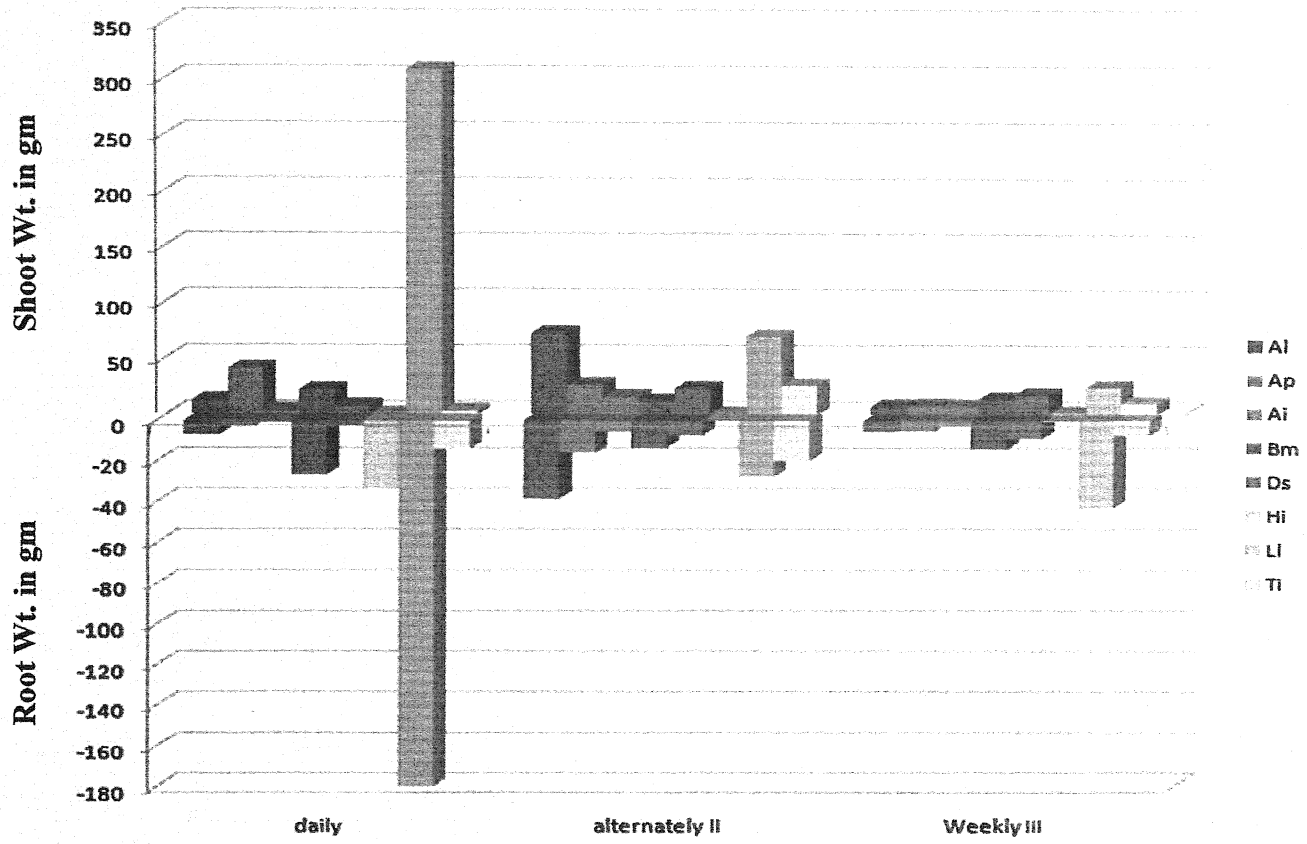
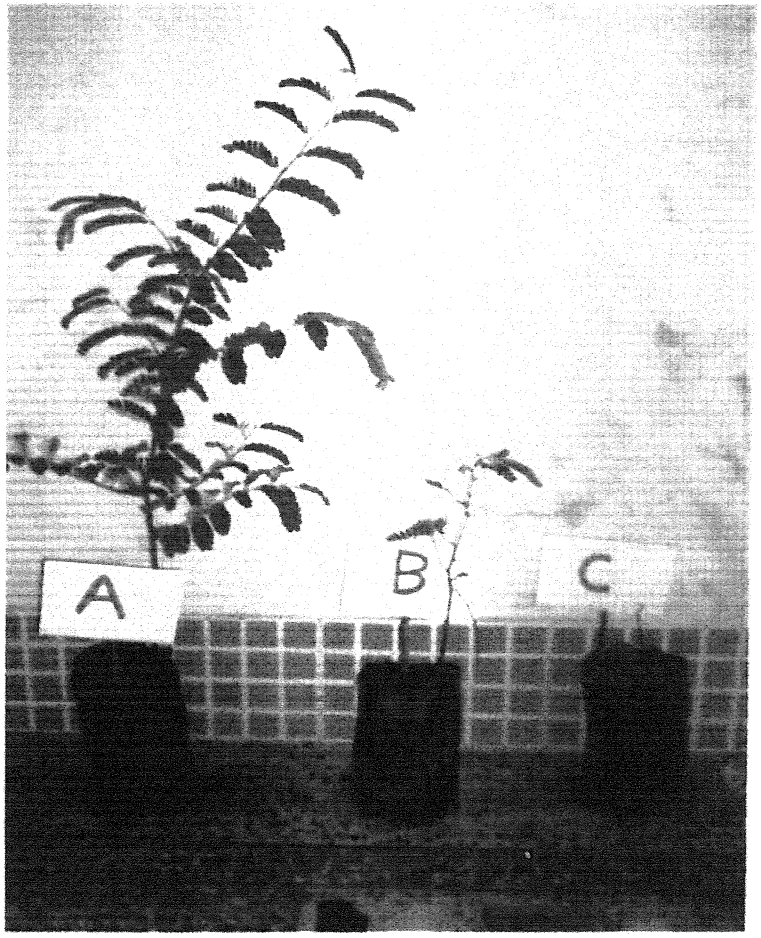
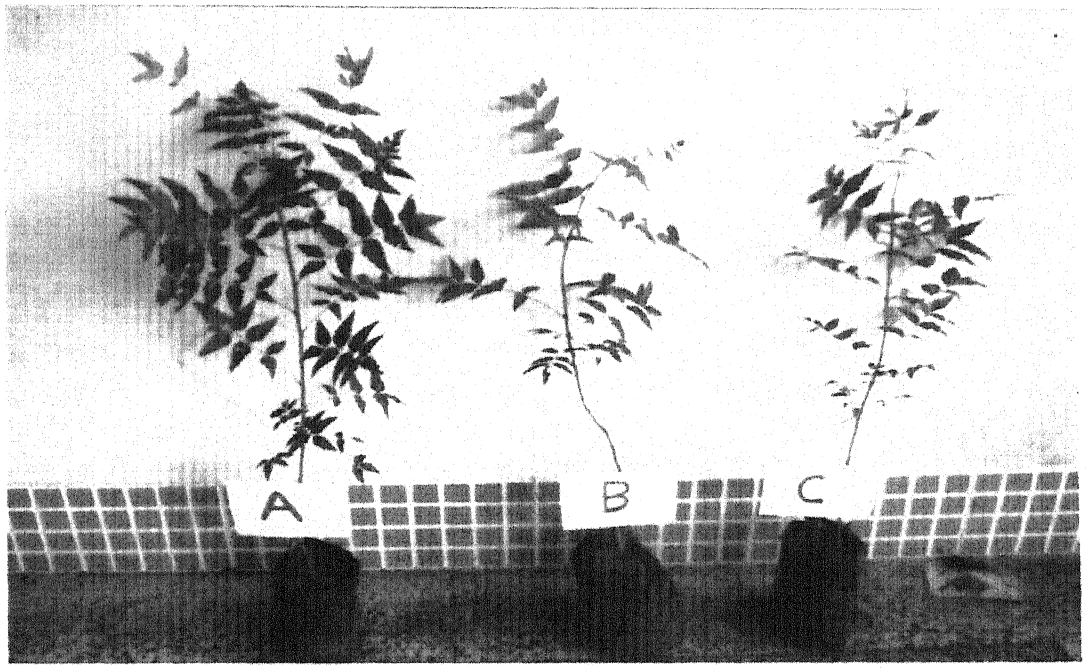


Fig. : 12 Effect of different irrigation conditions on Root & Shoot Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

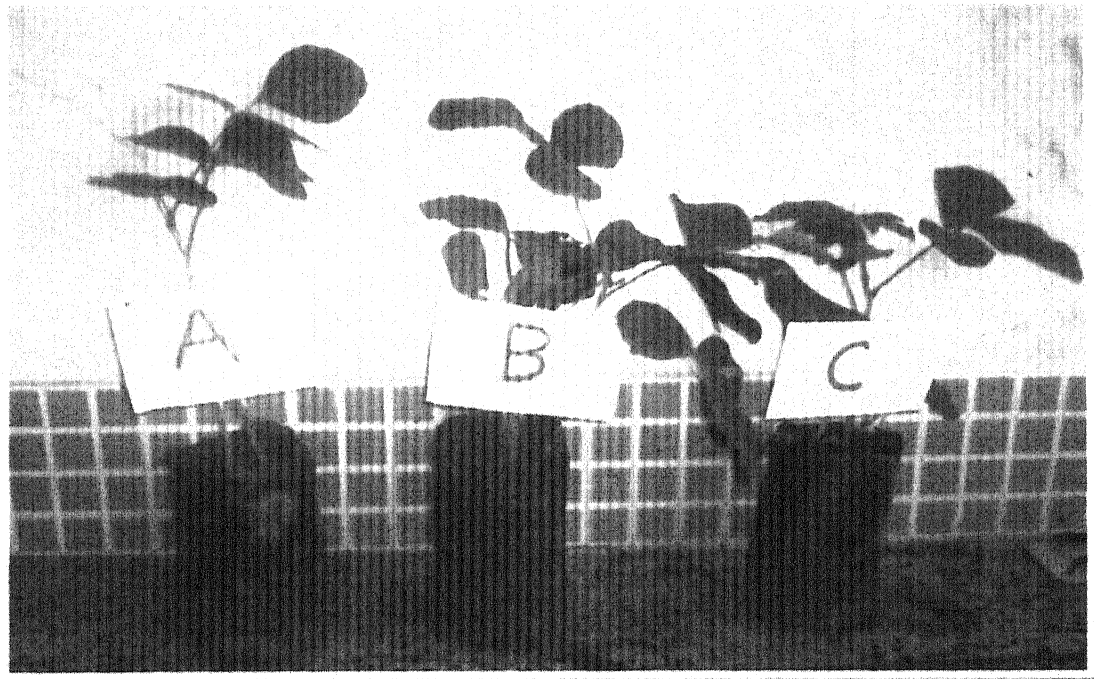
Effect of different Irrigation conditions on one year old seedling of *Albizzia lebeck*



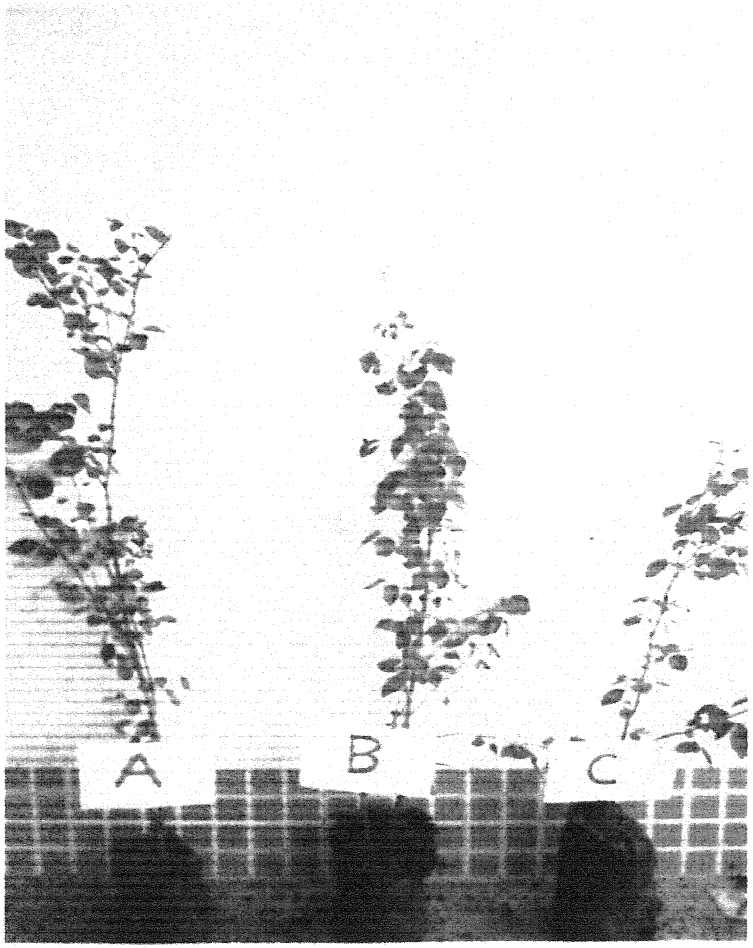
Effect of different Irrigation conditions on one year old seedling of *Albizzia procera*



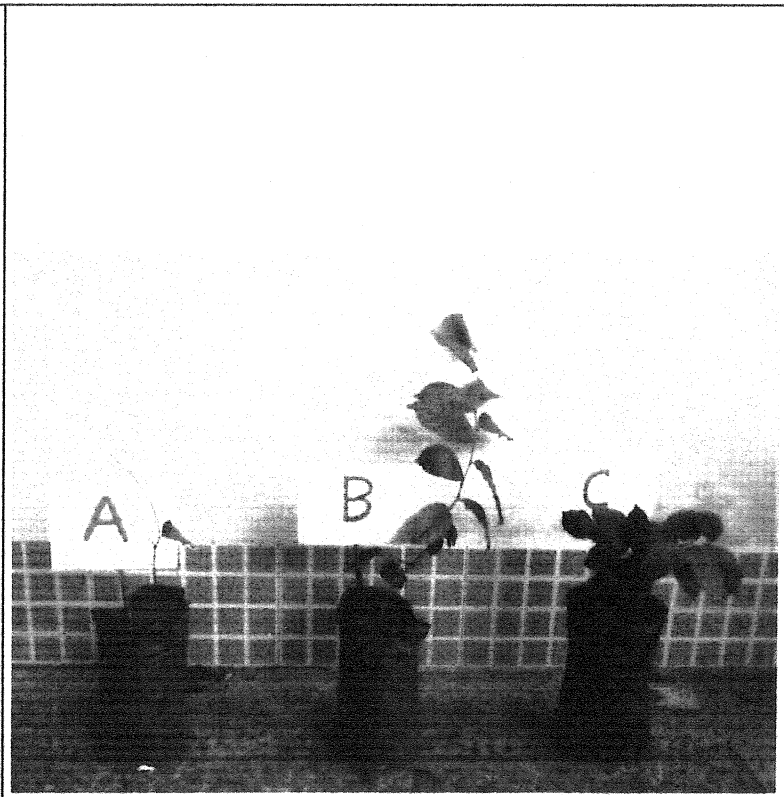
Effect of different Irrigation conditions on one year old seedling of *Azadirachta indica*



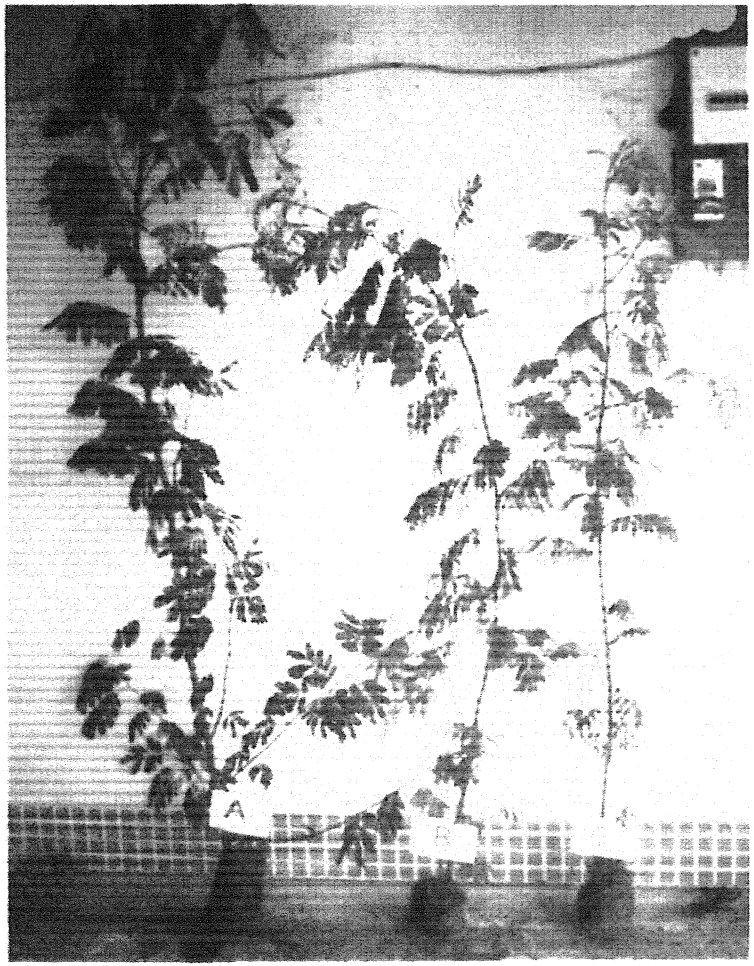
Effect of different Irrigation conditions on one year old seedling of *Butea monosperma*



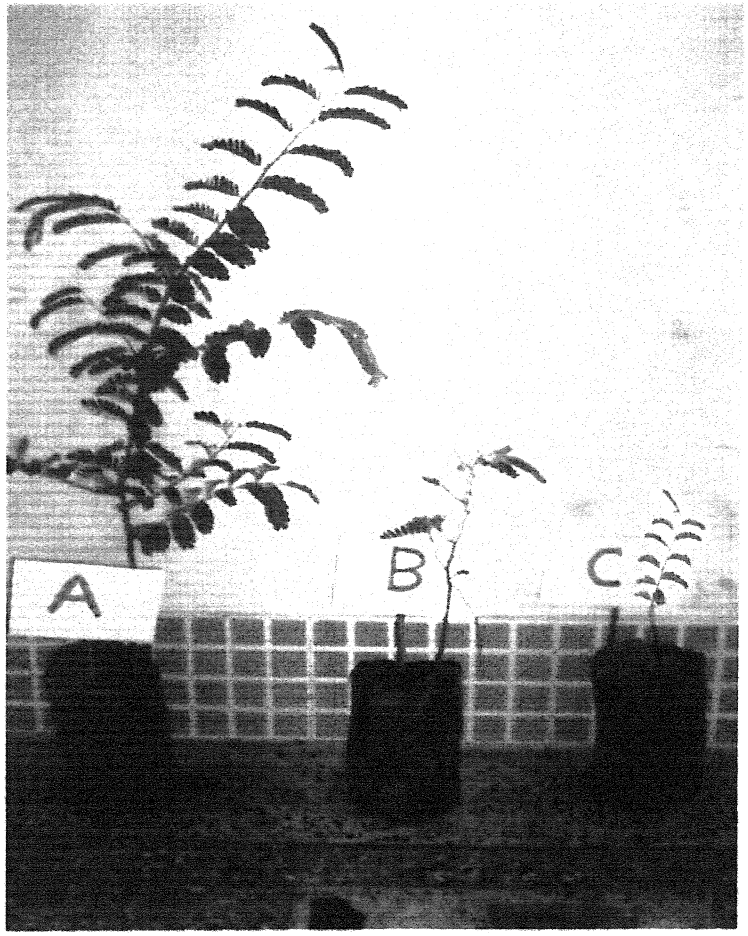
Effect of different Irrigation conditions on one year old seedling of *Dalbergia sissoo*



Effect of different Irrigation conditions on one year old seedling of *Holoptelia integrifolia*



Effect of different Irrigation conditions on one year old seedling of *Leucaena leucocephala*



Effect of different Irrigation conditions on one year old seedling of *Tamarindus indica*

weight of root and shoot was higher (89.2 gm and 30.9 gm) in case of I category of irrigation. The total dry weight /seedling were found to be higher in II categories of irrigation. The higher number of leaves were observed in seedlings of I category of irrigation, which declines gradually from II to III category.

In any phase of plant life the production of dry weight as compared to length, number etc. is more meaningful and an important aspect in the establishment of plant life in the natural condition. The strength and vigour of plant is represented by the weight and more appropriately say by dry weight therefore, on the basis of above observations it can be concluded that on average the growth of seedlings of all the species was found in alternate irrigation (II category).

The better growth performance of seedlings in alternate irrigation would have resulted due to setting better environment of soil (i.e. moderate moisture content and proper aeration condition) to the seedlings of these species, while the seedlings of daily irrigation might have suffered with low aeration and excessive wet soil condition which might have slowed down the growth of seedlings. Similarly the twice /weekly irrigation seedlings except *Leucaena* would have suffered with low moisture availability which might have checked the proper growth of seedlings in all the cases except *Leucaena leucocephala.*

A number of studies on soil moisture supply and aeration in relation to seed germination and growth of seedlings have been carried out by many workers. Stansky and Wilson (1967), Herbal and Sosebee (1969) Dickson (1972), Roger and Tanaka (1976), Seth and Srivastava (1972) pointed out a close relationship among moisture supply and nutrient update of plant in Sal seedling. Jeglum (1979) studied the effect of seed bed types and watering frequency on germination and growth of black spruce. Singh et al. (1989) studied the effect of irrigation on green and dry matter production in summer forage.

Soil is an important factor for the establishment and survival of a species. Root system of plants as well as soil is equally important, since soil is the medium in which roots grow, anchor the plants and from which the plants drew water and nutrients as such the importance of soil properties in the plant environment is of great significance. The growth and quality of forest, (wheather naturally occurring or artificially created)

depends basically on the physical and nutrient status of the soil. Work on seedling establishment, survival and soil characteristics in relation to seedling growth is scarce.

The data of seedlings growth in relation to different potting media are given in table no 14 (A),(B) and figure no 14 which revealed that maximum dry weight of root and shoot (100 gm and 565 gm) i.e.) of seedlings was found in medium S_8 in case of *Leucaena luecocephala.*

The table depicted represents dry weight of individual species in decreasing order for their best supplementing soil medium. Dry weight of shoot and root in all the cases was found maximum in the medium S_7 followed a decreasing trend with medium $S_5>S_2>S_6$ respectively. This may be due to setting better aeration and appropriate soil moisture which favours the growth of seedlings of species.

S_3 medium was found most unsuitable for Azadirachta seedlings as they exhibit negligible growth performance in it. On the other hand seedlings of *Azadirachta indica* and *Tamarindus indica* were doing well only in their particular medium i.e. S_3 and S_7 respectively.

There is no relation between the number of leaves/seedling with potting media used. No trend of any relaton of root/shoot dry weight ratio with potting media could be detected as there was much variation in the data of seedlings of almost all the species as regards to different potting media tried for their growth. Datas are represented in the tables.(14 (a) & (b))

Species	Root Dry wt. (g)	Shoot Dry wt. (g)	Soil medium
Leucaena leucocephlia	100	56.5	S_7
Albizzia procera	31.5	84.8	S_5
Albizzia lebbek	31.5	53.5	S_5
Butea monosperma	52.8	20.98	S_7
Holoptelia integrifolia	18.2	39.45	S_6
Dalbergia sissoo	10.25	32.75	S_2
Tamarindus indica	4.50	13.2	S_2
Azadirachta indica	4.2	7.75	S_7

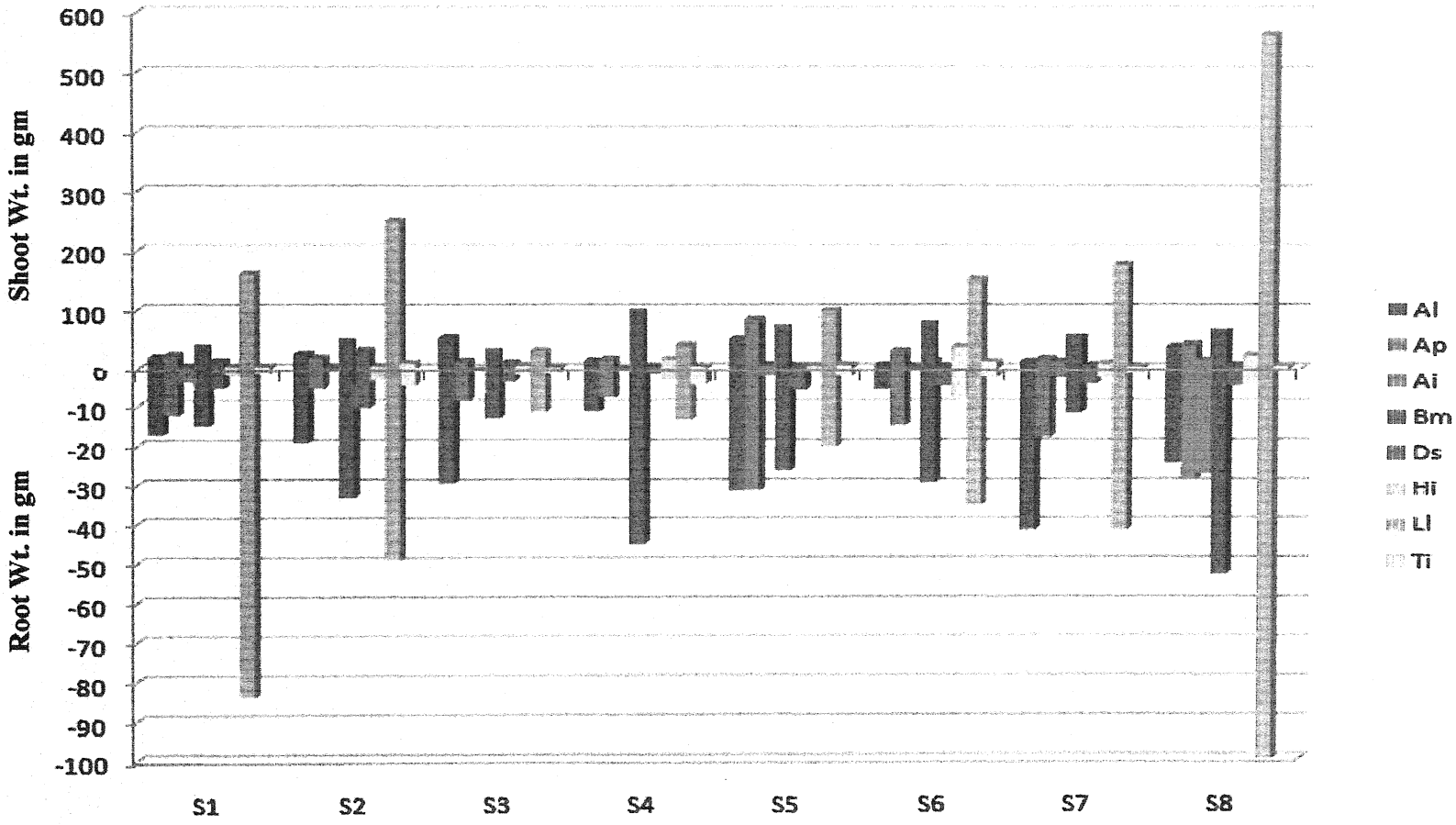


Fig. : 13 Effect of different Soil conditions on Root & Shoot Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

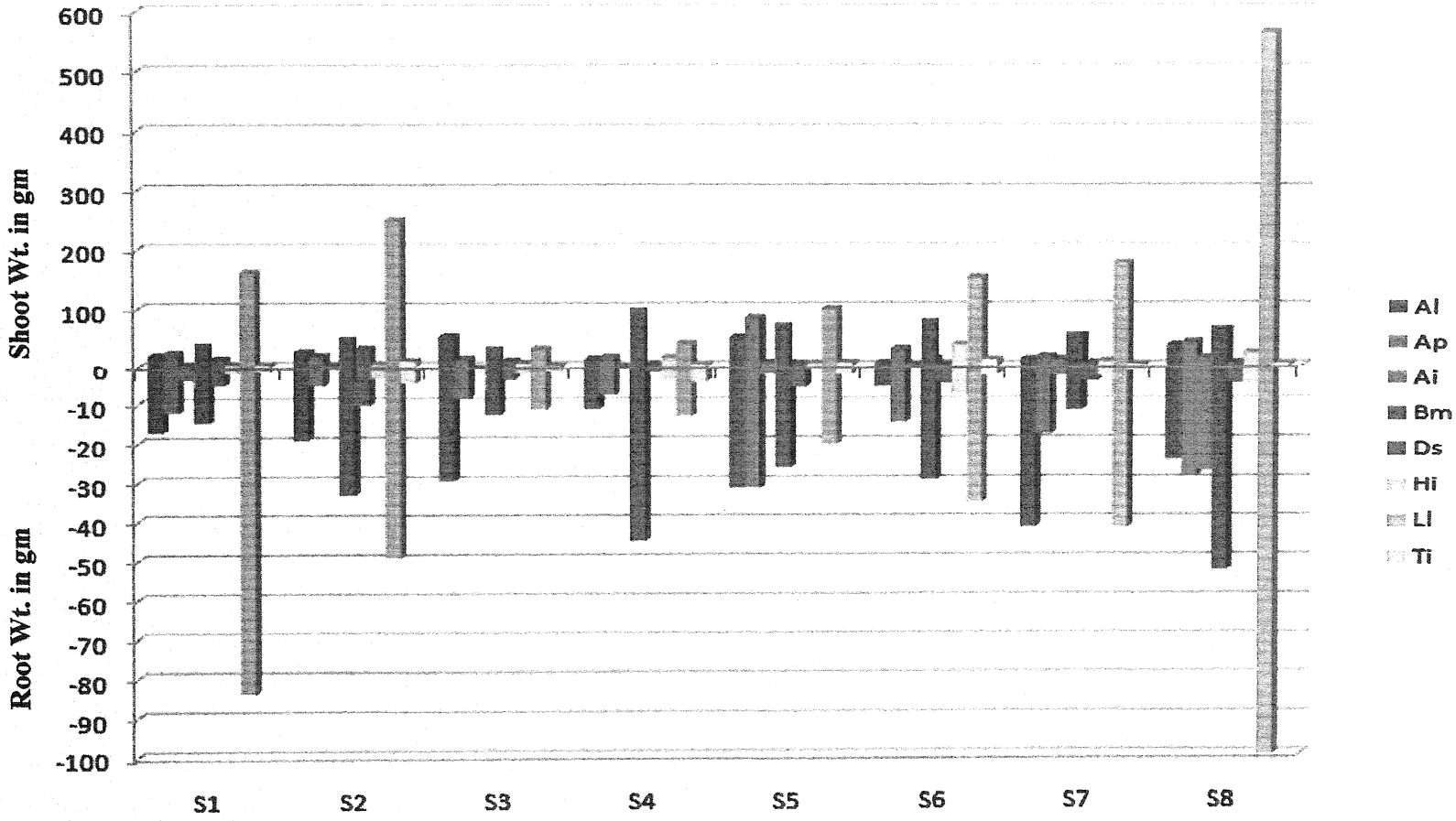


Fig. : 14 Effect of different Soil conditions on Root & Shoot Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

Table no. 14 (a) Effect of different Soil compositions on (various growth parameters)of one year old seeding of *Albizzia lebbeck(Al) Albizia procera(Ap.)Azadirachta indica (Ai), Butea monosperma (Bm),* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Red Soil (S1)				Black Soil (S2)				Sandy Soil (S3)				Sand + Red Soil (S4)				Red + Black Soil (S5)				Sand + Black Soil (S6)				Sand + Black + Red Soil (S7)				Fertilizer (S8)			
	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm	Al	Ap	Ai	Bm	Al	Ap	Ai	B	Ai	Ap	Ai	B	Ai	Ap	Ai	B	Ai	Ap	Ai	B
Root Length(cm)	38.5 ±3.28	65.6 ±1.84	25.4 ±1.68	55.8 ±1.98	47.5 ±2.49	37.5 ±1.80	20 ±1.77	90 ±2.70	50 ±2.76	40 ±2.27	-	60 ±2.35	30 ±2.83	39 ±2.35	11 ±1.41	31 ±1.63	76 ±1.41	86 ±1.84	40.5 ±3.62	65 ±2.06	38.5 ±2.64	44 ±3.49	29 ±1.65	55 ±1.77	47.5 ±2.69	27.5 ±2.26	50 ± 2.60	68 ±2.28	60 ±4.05	65 ±.1.84	35 ±1.77	76 ±3.96
Shoot Length(cm)	69 ±3.79	142±2. 06	50±2.6 0	43.5±2 .46	107.5± 4.11	74.5±1 .62	42 ±3.08	91 ±2.70	95 ±3.17	62.5 ±1.77	-	32.5 ±1.62	39.4 ±3.29	42.5 ±1.77	13 ±1.63	27 ±2.06	88.5 ±1.71	98.5 ±2.17	83 ±1.70	46 ±2.05	54 ±1.56	100 ±2.31	49 ±1.56	57.5 ±2.34	100 ±3.13	32.5 ±1.91	114 ±2.71	41 ±2.26	110 ±5.53	144 ±1.35	77 ±1.56	56 ±1.98
Plant Length(cm)	107.5 ±3.08	207.5 ±2.21	75.4 ±1.60	99 ± 2.15	155 ±3.18	112 ±2.13	62 ±2.21	92 ±2.70	145 ±2.28	102.5 ±1.98	-	42.5 ±2.52	69.4 ±2.7	81.5 ±0.87	24 ±2.01	58 ±2.03	764.5 ±3.05	184.5 ±2.33	123.5 ±1.84	111 ±1.41	92.4 ±2.41	144 ±2.63	78 ±2.28	62.5 ±1.56	147 ±52.9	60 ±2.48	164 ±2.31	109 ±1.53	170 ±3.4	179 ±2.2	112 ±1.93	132 ±2.13
No.of Branches	9.5 ±1.77	12.5 ±1.77	11 ±1.77	3.5 ±0.18	11.5 ±1.80	9 ±1.74	11 ±2.30	93 ±2.70	16 ±32.48	13.5 ±1.77	-	3.5 ±0.2	15.2±2 .49	17.5±1 .22	8±.198	2±0.53	12 ±2.06	12 ±2.09	27.5 ±2.15	4.5 ±0.50	6.5±1. 95	13±2.0 8	13.5±1 .62	5 ±0.45	20±2.6 9	5.5 ±0.77	28±2.3 3	4 ±0.61	14±2.5 3	19±1.9 8	18±1.7 7	9 ±1.77
Shoot/Root ratio	1.79 ±0.16	2.167 ±0.06	1.968 ±0.49	0.77 ±0.09	2.263 ±0.048	1.986 ±2.24	2.1 ±0.49	94 ±2.70	1.9 ±0.08	1.562 ±0.26	-	0.77 ±0.09	1.31 ±0.07	1.089 ±0.019	1.18 ±0.63	0.87 ±0.16	1.16 ±0.04	1.145 ±0.21	1.04 ±0.61	0.70 ±0.15	1.40 ±0.10	2.27 ±0.17	1.68 ±0.68	1.046 ±0.41	2.0 ±0.07	1.81 ±0.2	2.28 ±0.70	0.60 ±0.51	183 ±0.01	1.75 ±0.27	2.2 ±0.70	0.73 ±0.15
Root fresh wt.(g.)	27 ±3.26	20.25 ±2.47	72 ±2.32	26.75 ±2.06	37.5 ±2.01	10.75 ±0.22	1.5 ±1.20	95 ±2.70	56.5 ±2.91	16 ±2.04	-	26.75 ±2.06	21.4 ±3.67	15.5 ±2.04	1.5 ±0.77	4 ±0.77	53 ±3.16	53 ±1.65	4.75 ±0.70	50 ±0.70	13.25 ±1.77	27 ±1.41	1.75 ±0.75	45.75 ±2.37	69.5 ±3.52	20.8 ±1.45	5.5 ±0.71	33 ±2.35	45.5 ±2.42	50 ±2.54	8.0 ±1.51	91.5 ±3.09
shoot fresh wt(g.)	44.5 ±2.4	49.5 ±2.57	7.5 ±1.10	14.5 ±1.98	67.75 ±2.84	28.5 ±1.20	5.5 ±1.51	96 ±2.70	115.5 ±4.20	20.75 ±1.77	-	12.5 ±1.98	27.5 ±2.86	37.75 ±1.62	3.5 ±1.8	15 ±1.96	88.5 ±3.72	168.24 ±1.78	19.75 ±2.25	15 ±1.41	16.25 ±1.78	63.5 ±1.2	6.5 ±1.49	25 ±1.77	28 ±3.4	41.5 ±1.62	31 ±2.31	18 ±2.9	81.5 ±2.12	87.5±1 .41	27 ±2.35	39.5 ±1.84
Root Dry wt.(g.)	17.2 ±1.56	12.2 ±0.89	3.7 ±1.50	14.8 ±0.83	19 ±1.69	5.24 ±0.23	0.75 ±0.9	97 ±2.70	29.5 ±2.44	8.5 ±0.28	-	12.8 ±1.01	11.2 ±1.39	7.8 ±0.22	0.82 ±0.22	45 ±1.41	31.5 ±2.52	31.5 ±0.5	2.25 ±2.73	26.25 ±2.08	5.40 ±0.72	14.75 ±0.17	0.75 ±0.90	29.4 ±2.13	41.5 ±0.8	17.9 ±0.28	2.5 ±0.73	11.5 ±1.44	24.5 ±2.5	28.5 ±1.49	27.04 ±1.76	52.8 ±2.8
shootDry wt(g.)	20.9 ±2.06	25.2 ±1.80	3.51 ±1.8	7.2 ±1.43	26.52 ±1.76	20.2 ±1.47	2.5 ±0.73	98 ±2.70	53.5 ±1.71	14.5 ±0.19	-	5 ±1.42	14.5 ±1.77	17.98 ±1.25	1.82 ±0.75	1.5 ±0.53	51.5 ±1.76	84.8 ±1.42	7.75 ±1.06	6.9 ±1.42	7.29 ±1.60	31.75 ±2.07	2.75 ±1.40	14.2 ±1.52	13.75 ±1.93	18.4 ±0.30	14 ±1.63	8.5 ±1.60	37.9 ±21.9	42.8 ±1.28	16.4 ±1.67	20.98 ±1.77
Moisture %	46.7 ±1.42	46.37 ±1.78	53.92 ±1.78	46.66 ±1.98	56.75 ±2.47	35.18 ±1.36	60 ±2.0	99 ±2.70	51.74± 1.49	37.41± 1.51	-	55.34 ±1.56	46.62 ±1.41	47.74± 1.42	47.2 ±1.12	57.89 ±1.69	41.34 ±1.56	47.43 ±2.14	59.18 ±1.97	49 ±2	56.98 ±2.47	48.61 ±2.18	57.57 ±1.78	38.37 ±1.98	19.25 ±1.59	41.73 ±2.00	56 ±2.00	60.78 ±1.64	50.94 ±1.63	48.14 ±2.16	41.14 ±1.20	43.67 ±1.65
R/S dry wt.Ratio	1.21 ±0.18	2.91 ±1.39	2.91 ±1.39	0.48 ±0.43	1.35 ±0.18	3.85 ±0.14	3.33 ±0.81	100 ±2.70	1.81 ±0.22	1.70 ±0.42	-	0.39 ±0.45	1.33 ±0.18	2.34 ±0.08	2.21 ±0.43	0.23 ±0.33	1.63 ±0.10	2.69 ±0.22	3.44 ±2.80	0.26 ±0.32	1.35 ±0.09	2.15 ±0.41	3.66 ±1.66	0.48 ±0.31	51.51 ±0.09	5.6 ±1.37	5.6 ±1.37	0.73 ±0.30	1.53 ±0.09	1.50 ±0.3	3.90 ±1.63	0.39 ±0.32

Table no. 14 (b) Effect of different Soil [illegible]on (various growth parameters)of one year old seeding of *Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Red Soil (S1)				Black Soil (S2)				Sandy Soil (S3)				Sand + Red Soil (S4)				Red + Black Soil (S5)				Sand + Black Soil (S6)				Sand + Black + Red Soil (S7)				Fertilizer (S8)			
	D	H	L	T	D	H	L	T	D	H	L	T	D	H	L	T	D	H	L	T	D	H	L	T	D	H	L	T	D	H	L	T
Root Length(cm)	80 ± 3.53	26.5 ± 3.84	101 ±1.75	26.5 ±1.78	51.5 ±4.07	63.2 ±3.82	81 ±2.33	45 ±1.84	58 ±2.08	40± 4.97	75.2 ±1.91	45.5 ±2.28	38.5 ±1.04	48 ±4.73	86 ±1.92	48.5 ±2.35	31 ±1.41	50 ±2.18	77.5 ±2.56	41.5 ±2.5	35 ±2.11	52 ±3.72	85 ±1.56	47.5 ±2.31	40.5 ±3.64	43.5 ±2.84	126 ±3.56	32 ±1.88	38 ±3.54	44.7 ±3.13	150 ±4.19	45 ±0.41
Shoot Length(cm)	39 ± 2.97	30 ± 3.95	240 ±3.1	52.5 ±2.50	95 ±2.01	44.7 ±3.13	260 ±2.76	94.5 ±1.77	48 ±2.48	55± 3.73	141 ±2.12	54.5 ±1.56	85 ±0.70	105.5± 1.90	150.5± 1.98	69 ±3.21	66 ±6.05	68 ±2.82	2.45 ±2.87	85 ±1.56	77.5 ±4.03	105 ±2.53	265 ±4.23	100 ±2.68	80.5 ±4.15	68.5 ±4.20	269 ±2.61	63.5 ±1.84	75 ±5.08	65.9 ±4.20	34 ±4.19	58 ±1.7
Plant Length(cm)	119 ± 2.82	56.5 ± 3.22	341 ±2.76	79 ±2.22	156.5 ± 2.04	80.9 ±5.30	341 ±4.19	9 ±1.41	106 ±2.12	95± 3.14	216 ±2.26	100 ±2.78	123.5± 0.71	153.5± 2.84	286.5± 2.05	117.5± 2.55	9.7 ±2.63	118 ±2.26	322 ±3.19	126.5± 1.84	112.5± 4.67	157 ±2.88	350 ±2.83	147.5 ±1.6	120 ±3.61	112 ±2.74	395.5 ±2.13	95.5 ±1.98	113 ±4.94	11.8 ±3.60	490 ±3.53	103 ±1.63
No.of Branches	19 ± 3.04	29 ± 2.66	42.5 ±2.27	29 ±1.88	19.5 ±2.03	27 ±2.42	73 ±1.20	47.5 ±1.38	18.5 ±2.76	18± 2.70	35 ±3.53	22 ±.1.63	18 ±3.33	27±2.5 7	33.05± 2.05	36.5 ±1.64	24.5 ±2.61	21 ±1.26	54 ±2.50	37 ±1.65	17.5 ±3.42	22 ±1.99	50 ±4.47	53.5 ±1.84	16.5 ±3.54	17 ±0.20	52.5 ±3.12	31 ±2.35	14 ±0.86	20 ±2.44	71 ±6.89	42 ±2.47
Shoot/Root ratio	0.487 ± 0.01	1.132 ± 1.71	2.37 ±0.04	1.981 ± 0.34	1.84 ±0.02	1.23 ±0.04	3.209± 0.02	2.01 ±0.34	0.827 ±0.02	1.37± 0.03	1.87 ±0.02	1.19 ±0.21	2.207 ±0.01	2.197± 0.10	1.75±0. 02	142.2± 0.30	2.12 ±0.04	1.36 ±0.02	3.16 ±0.01	2.04 ±0.4	2.21 ±0.05	2.019± 0.02	3.11 ±2.02	2.105 ±0.4	1.98 ±0.07	157 ±0.03	2.13 ±0.02	1.98 ±0.32	1.97 ±0.07	1.47 ±0.03	2.26 ±0.01	1.28 ±0.30
Root fresh wt.(g.)	10.75 ± 0.04	3.5 ±0.14	179.5± 2.97	3.5 ±0.32	20.75± 0.04	5.5 ±0.29	84.5 ±2.69	6.75 ±2.29	7.25± 0.09	4.5 ±0.44	21.5 ± 1.73	3.5 ±0.26	4.75± 0.68	8.5 ±0.35	23.5±2. 34	3.75 ±2.26	11.5 ±1.20	3 ±0.70	38.5 ±2.14	3.75 ±0.26	10 ±2.20	15.5 ±2.63	12.47 ±0.12	4.5 ±0.45	6.75 ±0.39	6.5 ±.78	66.5 ±2.76	2.5 ±0.78	8.5 ±0.76	10.5 ±0.18	217 ±2.26	2 ±0.79
shootfresh wt(g.)	20 ±0.70	11.75± 0.05	439.75 ±2.27	11.75 ±1.21	52.25± 2.20	12.2 ±0.38	402.5± 3.05	24.5 ±2.0	17.75 ±2.00	14.5 ±082	76.5 ±1.89	5.75 ±2.43	14.5 ±2.27	41 ±3.96	86.25± 1.56	9.5 ±1.56	13.5 ±1.01	14 ±0.80	219.5± 2.53	15.25± 1.91	12.25± 1.57	74.5 ±4.67	291.25 ±2.5	24.5 ±2	12 ±3.18	22.5 ±2.23	334 ±1.77	11.5 ±0.41	15.5 ±3.14	42.5 ±2.23	10.29± 3.76	10.5 ±0.70
Root Dry wt.(g.)	5.1 ±0.01	2 ±0.35	84 ±1.19	1.5 ± 0.85	10.25± 0.03	3.39 ±0.04	49.25± 2.97	4.50 ±2.60	3.5 ±0.88	2 ±0.32	11.4 ±0.53	1.5 ±0.85	1.5 ±0.19	3.5 ±0.073	13.25± 1.56	4.25 ±2.61	5.45 ±0.08	1.2 ±0.12	20.25± 2.56	2.25 ±2.8	4.5 ±2.12	7.75 ±0.31	35.15 ±2.62	2.5 ±1.41	4 ±0.58	2.75 ±0.16	41.75 ±2.26	1.5 ±0.85	4.5 ±0.65	4.8 ±3.40	100 ±3.53	1 ±0.95
shootDry wt(g.)	14.2 5 ± 0.02	6.14 ±0.05	162.5± 3.26	5.25 ± 1.59	32.75± 2.01	6.24 ±0.15	250.5 ±2.97	12.2 ±1.62	11.25± 0.85	7.82 ±0.20	32.5 ±2.44	2.75 ±0.90	5.75 ±0.19	17.8 ±0.23	41.65± 2.40	5.25 ±1.59	6.25 ±0.03	7.2 ±0.49	100.4± 4.48	8 ±2.54	5.50 ±0.23	39.45 ±082	153.25 ±6.43	13.5 ±1.63	7.25 ±0.13	10.28 ±0.36	177.5 ±2.50	5.25 ±0.59	7.24 ±0.11	25.2 ±3.40	565 ±3.54	6.5 ±2.62
Moisture %	37.07 ±0.04	46.62 ±2.96	60.19± 2.30	53.96 ± 2.56	41.09± 1.77	45.59 ±2.99	38.44 ±2.47	46.56 ±3.75	41.04± 1.77	48.31± 2.94	55.20 ±2.77	54.05 ±2.57	62.33 ±2.09	56.96± 4.56	49.65± 2.34	28.30± 1.63	53.20 ±2.06	50.58 ±2.97	53.23± 3.88	46.05± 1.92	55.05± 0.93	57.55 ±2.94	37.88 ±2.48	45.86 ±1.92	40 ±0.03	55.06 ±4.49	49.25 ±3.48	51.78 ±2.56	51.08± 6.39	43.28 ±3.12	56.62± 0.04	48 ±2.7
R/S dry wt.Ratio	2.70 ± 2.27	3.07 ±0.36	2.62 ±0.02	3.5 ±0.92	3.19 ± 0.05	1.84 ±2.26	5.06 ±0.03	2.71 ±0.90	3.21± 0.021	3.91 ±0.35	2.85 ±0.02	1.83 ±0.91	3.21 ±0.04	5.08 ±0.56	3.15 ±3.05	1.23 ±0.94	1.14 ±0.04	6 ±0.44	4.95 ±0.32	3.66 ±1.28	1.22 ±0.06	5.09 ±0.22	4.34 ±0.08	5.28±1. 29	1.81 ±0.03	3.73 ±0.34	4.25 ±0.07	3.5 ±0.56	1.60 ±0.08	5.25 ±0.21	5.65 ±0.03	6.5 ±1.47

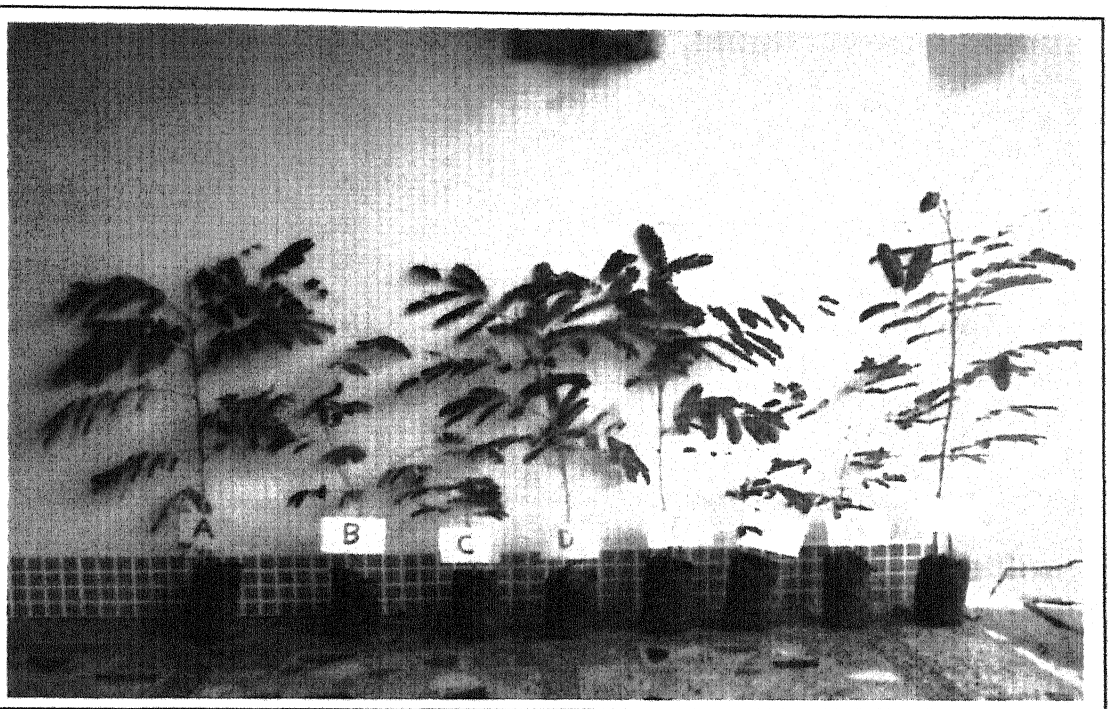
Maximum shoot length was observed in *Leucaena leucocephala* (269 cm) followed by *Albizzia procera* (142 cm) *Azadirachta indica* (114 cm), *Albizzia lebbek* (110 cm) *Holoptelia integrifolia* (105.5 cm), *Tamarindus indica* (100 cm), *Dalbergia sissoo* (95 cm) and *Butea monosperma* (57.5 cm) in decreasing order.

The medium S_7 is supposed to be an appropriate medium for obtaining good length of shoot in most of the species except *Albizzia procera* and *Dalbergia sissoo* which showed good performance of their shoot length in the media S_1 and S_2 respectively. Observed root length for all the species in decreasing order with their best soil type is depicted as follows:

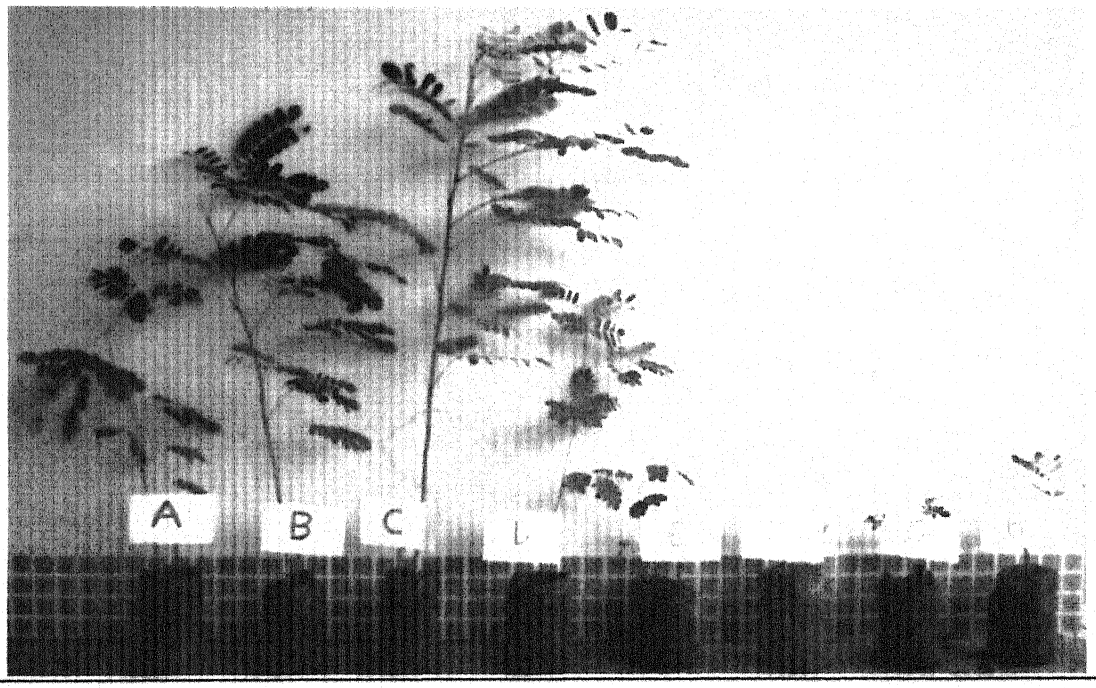
Species	Root length	Soil type
Leucaena leucocephala	150cm	S_7
Butea monosperma	90cm	S_2
Albizzia procera	86cm	S_7
Dalbergia sissoo	80cm	S_2
Albizzia lebbek	76cm	S_6
Holoptelia integrifolia	52cm	S_7
Azadirachta indica	50cm	S_7
Tamarindus indica	48.5cm	S_6

This may be due to better aeration and appropriate water retaining capacity of the medium S_7, which is favourable for the growth of these species. Contrary to this minimum growth in medium (S_4) may be due to lesser aeration and more water retaining capacity than earlier ones. Joshi (1960) studied the effect of soil type on the growth of *Anogeissus latifolia*. Better growth performance of *Tectona grandis* seedling in black soil is studied by Yadav et. al (1982).

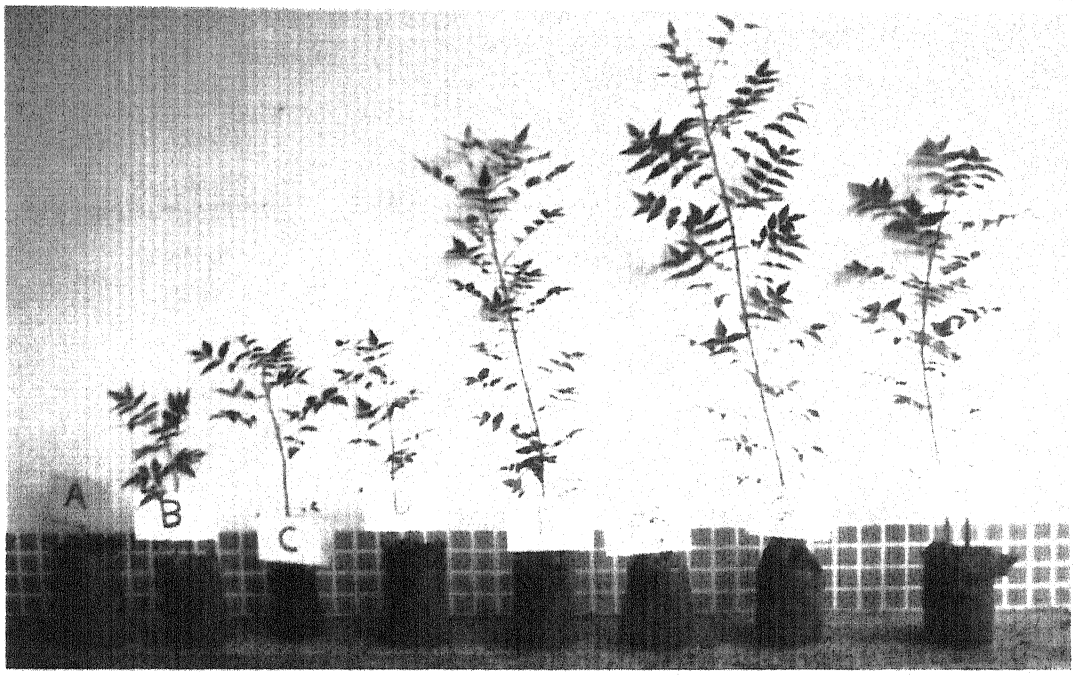
The deficiency or excess of any element in potting mixture may cause adverse effect on the growth of the seedlings. Srivastava et al. (1998) worked out the selection of proper potting mixture for raising *Acacia nilotica* seedling under root trainer seedling production system. Ginwal et al. (2001) studied the effect of potting media for raising *A. nilotica* and concluded that in respect of sand, soil and compost, combination of sand and compost in the ratio of 1:4(20% sand+80% compost) gives best results. Testing the



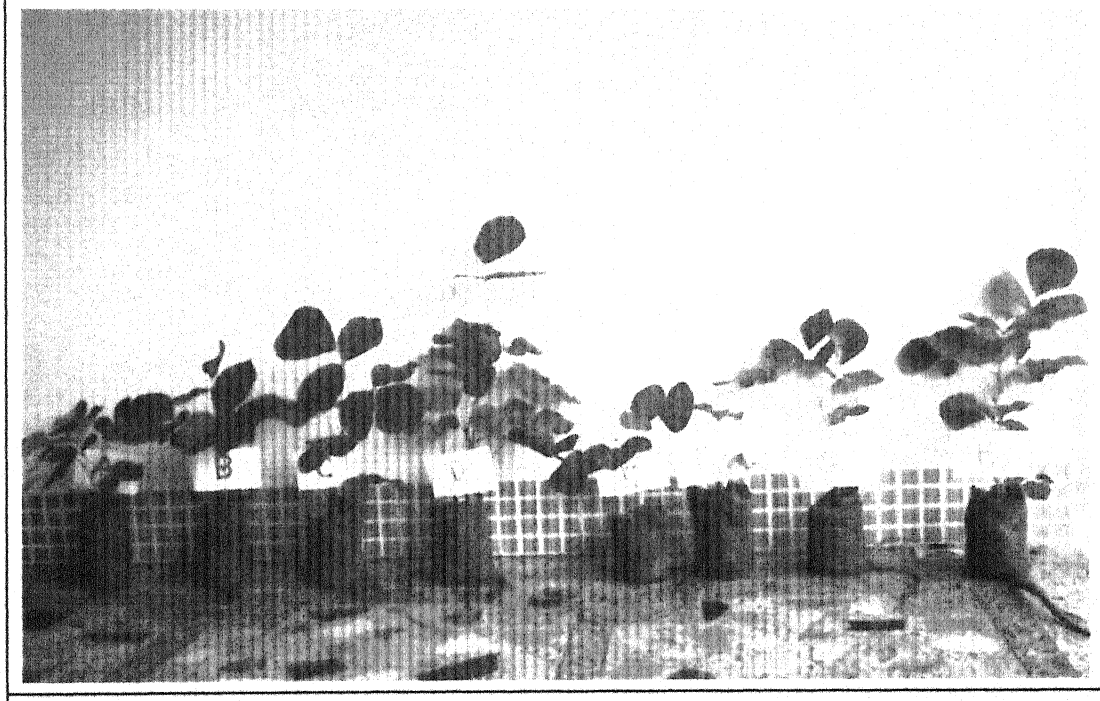
Effect of different Potting media on one year old seedling of *Albizzia lebbeck*



Effect of different Potting media on one year old seedling of *Albizzia procera*

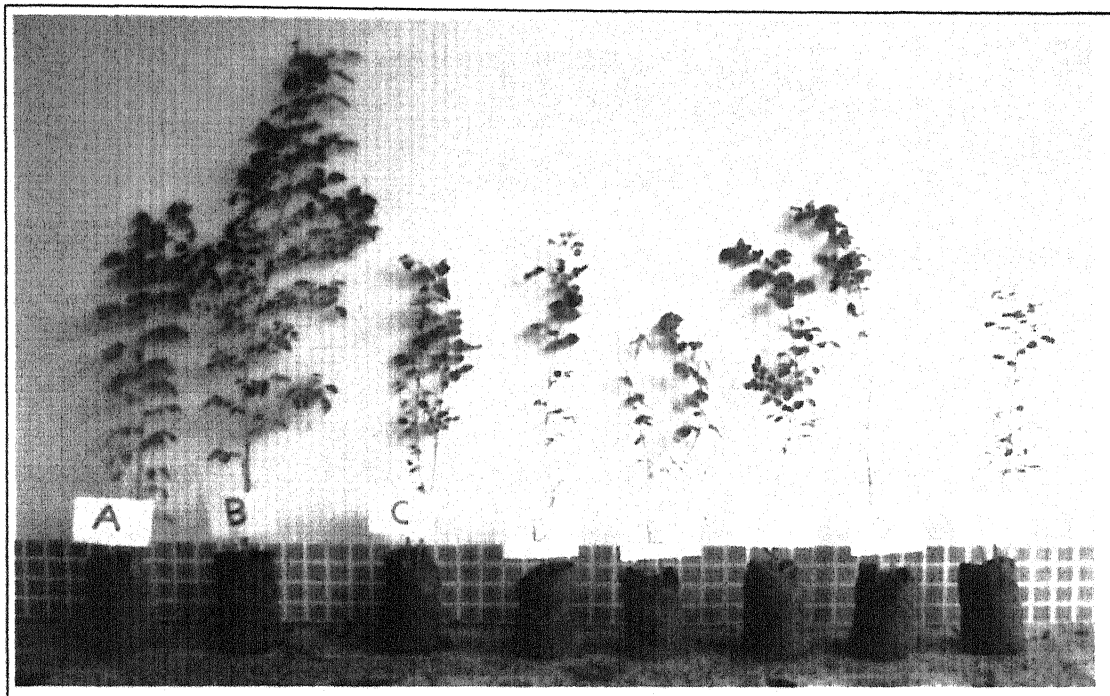


Effect of different Potting media on one year old seedling of Azadirachta indica

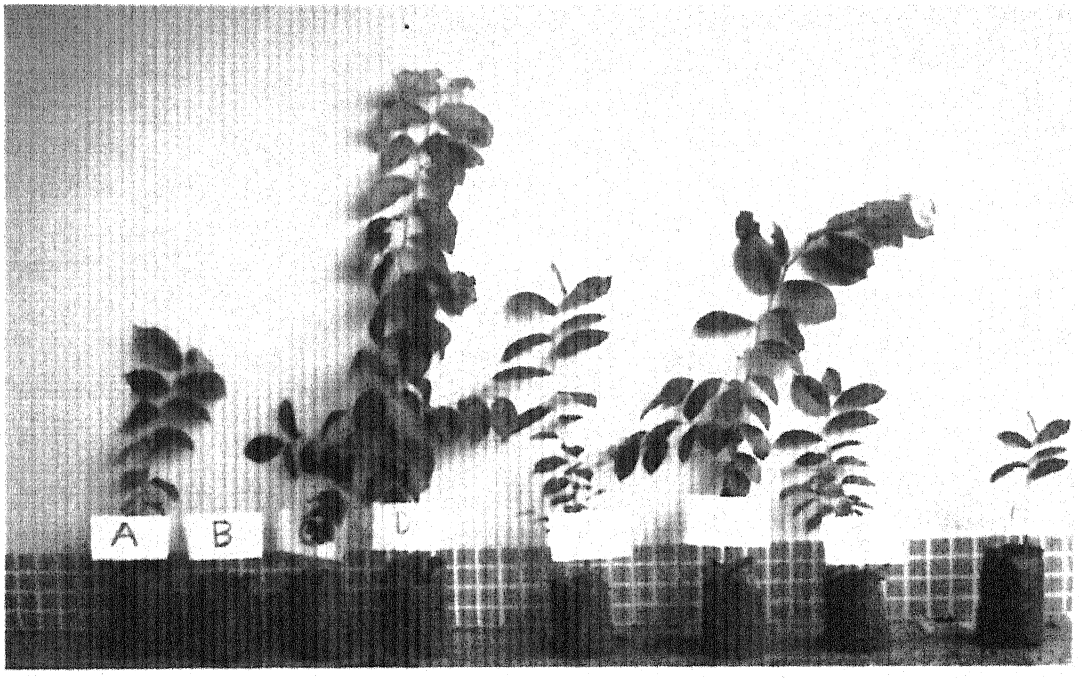


Effect of different Potting media on one year old seedling of *Butea monosperma*

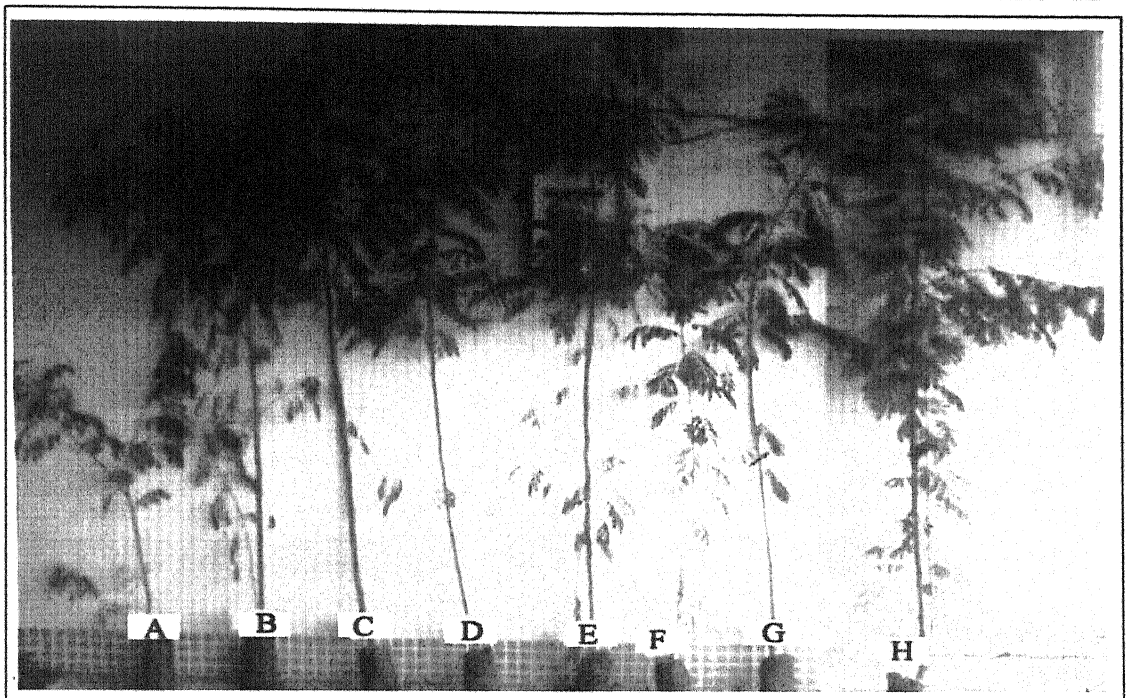
Plate - 31



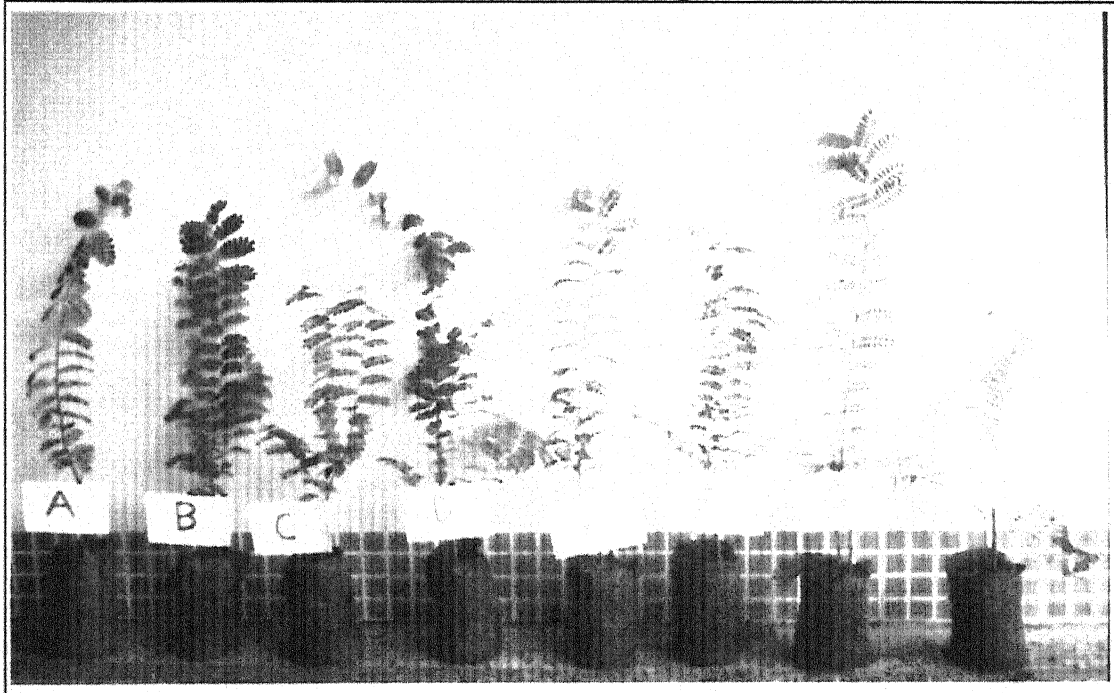
Effect of different Potting media on one year old seedling of *Dalbergia sissoo*



Effect of different Potting media on one year old seedling of *Holoptelia integrifolia*



Effect of different Potting media on one year old seedling of *Leucaena leucocephala*



Effect of different Potting media on one year old seedling of *Tamarindus indica*

organic ingredients, combination of charcoals and compost in the ratio of 1:4 (20% charcoal + 80% compost) was considered another good growing medium for the said process. Thus two potting mixture with different ingredients were standardized. The results on use of pure compost as a potting medium were not much appreciable. The compost is required to be supplemented with 20% charcoal or 20% sand for making it more effective in raising *Acacia nilotica* seedlings. Improper choice of potting mixture may result in poor quality seedling production in nurseries.

Some preliminary work was done by Troup(1921) Anthony(1989) has observed poor growth of *Pinus caribaea* seedling in clay soil due to its poor porosity as compared with peat soil. Further, Eaves and Payne (1969) have identified the importance of a number of soil factors upon the growth performance of root at early stages. Seth and Srivastava (1972) have also studied importance of different soil factor in relation to root development. Heydecker (1979) has reported that the garden soil and sand mixture (2:1) and sand humus mixture (1:1) appeared to be most satisfactory potting media for the growth of *Pindorosa rupa.*

Eaves and Payne (1989) have observed that soil texture has profound influence on root growth particularly at seedling stage. Different ratio of soil mixture has been recommended by various workers for different species (Evans 1983; Bahuguna and Lal 1990; Roy, 1986). Apart from soil, fertilizers also exert a pronounced effect on the growth of root and shoot in certain species (Swetzer and Nelson, 1963). The improved mineral nutrition during establishment may increase root growth of seedling (Roy et al 1984). However, the optimum requirements for different fertilizers vary with the species as well as soil fertility level.

Sabale et al. (1995) has discussed the effect of different potting media on germination, propagation, growth and moisture content of *Mentha longifilia.* More recently Tiwari et al. (2001) recorded the effect of different potting media and concluded that the best growth media was soil and sand (S_2) in equal proportion for all selected species. Better results in S_2 were due to good aeration and suitable moisture content. Potting medium is the most important input for containerized seedling production. It is responsible for healthy and uniform seedling production. Apart from the selection of proper ingredients, it is necessary to maintain the porosity of the potting mixture so that

proper development of root takes place. (Srivastava et al., 1988). The media should be rich enough to sustain seedlings for about 90-120 days. A good potting medium is characterized by light weight, friability, good water holding capacity, drainage, porosity, slight acidity, low bulk density free from fungal spores and insects and low inherent fertility etc. (Chakravarthy et al., 1998). The primary ingredient for potting media in India is compost and high quality compost can be made from vegetative waste particularly forest weeds (Jones 1998). Preparation of suitable potting medium includes standardization of texture and nutrient status. There can be no standard mixture because the compost varies from nursery to nursery, therefore, a specific work is required to be done for developing a proper potting mixture, as regard to site and species concern.

According to Gera et al. (1999) *Dalbergla sissoo* is one such species whose distribution is profoundly influenced by edaphic factor rather than climatic factors. The tree comes up well on new sandy alluvial and well drained soils. Its good growth is noticed in porous and well aerated soils with adequate moisture. It prefers a medium of good drainage like mixture of soil and sand (2:1) ratio, but it is abortive in stiff clayey soil. According to Tripathi and Bajapi (1988), the growth performance of seedling of *Anogeissus pendula* was observed better in sand. They found red soil as second best medium for growth at early seedling stage.

Raman et al. (2008) concluded that combination of FYM and inorganic fertilizer gives optimum germination and survival percentage in raising seedling of *Gmelina arborea* Linn. as well as best expression in terms of growth and quality parameters. Application of higer level of inorganic fertilizers (100 mg. Urea + 100 mg. SSP + 50mg. MOP) in addition to FYM (12.5 gm.) per 500 gm soil mixture helped in better growth, development and quality of seedlings.

The type of soil mixture affects the growth and quality of seedlings of various tree species in the nursery (Bahuguna and Lal 1990 and Lenuwal and Dhawan, 1991). Among all the potting mixtures seedlings of *D. sissoo* indicated higher growth and dry weight in the potting mixture of soil sand, sand and FYM in 1:2:2 and 1:2:1 rate. It was also observed that seedling growth increased in all the combinations of FYM, soil and sand. The water holding capacity of FYM is always greater than the sand and soil individually or in combination, moreover, the FYM and inorganic fertilizer regulate nutrient uptake,

improve plant yield and physical status of soil (Lal and Mathur 1989; Kaberathunma et al. 1993). Thus the increased level of FYM in the potting mixture favours the growth of seedling. This is in confirmity with the findings of Bahuguna and Lal (1990) and Nautiyal et al. (1995) who have observed better growth of seedlings on the addition of FYM in soil mixture.

Yadav et al (1982) have also attributed higher water holding capacity to higher growth of *Tectona grandis,* on increasing the quantity of FYM in potting mixture but a proportion beyond 1:2:2 ratios of soil, sand and FYM was not much beneficial for the plant growth which can be attributed to the reduction of water holding capacity. The potting mixture with higher proportion of sand lacks aggregation because of which the container soil get dispersed at he time of planting leaving the seedling naked, which may result in poor survival.

Abod et al. (1979) found that air and soil temperature influence the root generation potential in *P. caribaea* markedly. Stansky and Wilson (1967) studied the effect of soil moisture and texture on root /shoot weight of transplanted pine seedling and stated that increasing clay content of soils and repeated droughts inhibited shoot and root development. Funk (1971) found better growth of black walnut seedling in conventionally shaped pots containing the 3:1 sand peat mixture. Similarly Montana et al. (1977) studied white fir seedling growth in relation to saw dust as potting medium and concluded that old sawdust and peat improved the seedling quality, while new sawdust reduced growth substantially. Rawinski et al. (1980) described the soil properties and coniferous seedling growth in North Wisconsin and concluded that soil organic matter; pH, texture and microclimate were related to growth. Minore et al. (1969) concluded that soil density influence the seedling growth in eight pacific north western tree species.

In looking back over the many heterogeneous effects on hormones on growth and the development of plants, it is evident that the variety and the range of response elicited by these substances are unique. In much of the work with hormones great diversity in type of response has been observed. The response obtained frequently depend on many factors such as the kind or variety of plants used, the part of the plants treated and its stage of development, the concentration of hormone and the kind of harmone applied. Gibberellic acid is known to influence a number of physiological processes in plants in

our country. This growth hormone has been tried against several agricultural and horticultural crops and their response is studied in many plant species.

An examination of data Table 15 (A) and (B) and Figure 15, 16 on the effect of hormone treatment (IAA) on seedling growth indicate the following features: *Leucaena leucocephala* (100 cm), *Butea monosperma* (74 cm), *Albizzia lebbek* (70 cm) *Holoptelia integrifolia* (50 cm), and *Tamarindus indica* (50 cm) have shown good length in the same concentration (25 ppm) except in *Dalbergia sissoo* (44 cm), where roots were of same length in 25 and 75 ppm concentration. Minimum response to IAA treatment was observed in *Albizzia procera* (40.8cm.) and *Azadirachta indica* (38 cm) in 25 ppm.

The response of IAA treatment on length of shoot was found almost same as of root, as they were showing good length in same ppm concentration and are depicted as follows: *Leucaena leucocephala* (230 cm), *Albizzia lebbek* (100 cm), *Dalbergia sissoo* (86 cm), *Holoptelia integrifolia* (77 cm) *and Azadirachta indica*). Minimum response to IAA treatment was observed in *Albizzia procera* (47.8 cm) in 25 ppm, except *Azadirachta indica* where the length of shoot was observed greater in both 25 and 75 ppm concentration.

No correlation between treatment of IAA concentration / number of branches/ seedling could be detected in any species as these were greatly vary with species to species and concentration.

Root fresh weight was found maximum in *Leucaena leucocephala* (63.5 gm) followed by *Albizzia lebbek* (46.5 gm), *Butea monosperma* (18.5 gm) and *Dalbergia sissoo* (15 gm) in 25 ppm concentration. Minimum response to IAA treatment was given by *Holoptelia integrifolia* and *Azadirachta indica* both (9.5 gm root weight) in 25 ppm concentration.

Shoot fresh weight was found maximum again in *Leucaena leucocephala* (255 gm) followed by *Albizzia lebbek* (52.5 gm), *Tamarindus indica* (27.5 gm), and *Azadirachta indica* (24 gm) in 25 ppm concentration except *Holoptelia integrifolia* (35 gm) and *Dalbergia sissoo* (29 gm) where the fresh weight of root was observed greater in both 50 ppm concentration. Dry wt. also followed the same pattern as found in fresh wt. catgory of different species, but no trend of relation between moisture content of shoot, root and IAA concentration was detected.

Table no. 15 (a) Effect of different IAA conditions on (various growth parameters)of one year old seeding of *Albizzia lebbeck(Al) Albizia procera(Ap.), Azadirachta indica (Ai) and Butea monosperma (Bm)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Control				25 ppm				50 ppm				75 ppm				100 ppm			
	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm	Ai	Ap	Ai	Bm
Root Length(cm)	30 ±1.41	31 ±2.47	32 ±1.98	30 ±1.62	46 ±1.85	38.7 ±2.02	38 ±2.13	74 ±2.78	35 ±1.07	35.4 ±2.6	30 ±1.77	63 ±2.09	44 ±2.39	40.8 ±2.17	34 ±1.20	45 ±1.85	42 ±2.47	34 ±2.53	27 ±1.41	58 ±1.42
Shoot Length(cm)	43 ±2.42	40 ±2.15	70 ±2.33	26 ±2.92	64 ±2.3	47 ±2.39	72 ±1.77	35 ±1.63	51 ±2.83	44.5 ±2.38	70 ±1.96	31 ±1.74	62 ±2.28	47.8 ±2.42	72 ±1.93	31 ±1.41	60 ±2.44	42 ±2.06	65 ±2.48	34 ±1.73
Plant Length(cm)	73 ±1.77	71 ±2.2	102 ±1.98	56 ±1.63	110 ±2.11	85.7 ±1.41	110 ±3.35	109 ±1.56	86 ±2.12	79.9 ±1.8	100 ±2.24	94 ±1.63	106 ±2.11	18.6 ±2.37	106 ±2.22	76 ±1.42	102 ±1.77	76 ±1.04	9.2 ±2.13	92 ±1.63
No.of Branches	12 ±1.98	14 ±1.77	20 ±2.41	4 ±1.41	15 ±2.2	15.1 ±0.77	23 ±2.47	6 ±1.41	14 ±2.16	14 ±2.21	25 ±2.73	5 ±1.41	17 ±1.33	15 ±2.22	22 ±2.60	5 ±1.41	19 ±1.43	15 ±1.41	19 ±2.61	5 ±1.41
Shoot/Root ratio	1.43 ±0.50	1.29 ±0.46	2.18 ±0.48	0.86 ±0.28	1.39 ±0.15	1.23 ±0.46	2.11 ±0.48	0.68 ±0.29	1.45 ±0.50	1.25 ±0.44	2.33 ±0.4	0.49 ±0.36	1.40 ±0.51	1.17 ±0.34	1.89 ±2.53	0.47 ±0.3	1.42 ±0.50	1.21 ±0.34	2.40 ±2.47	0.58 ±0.35
Root fresh wt.(g.)	7.5 ±0.29	2.31 ±0.98	9.5 ±1.77	14 ±1.63	21.5 ±2.17	2.5 ±0.97	7 ±1.80	16.5 ±1.25	9 ±1.15	3 ±0.97	5 ±1.50	18.5 ±1.42	20.5 ±2.14	3.5 ±2.98	2.5 ±1.78	18.5 ±1.28	18.5 ±2.14	5.5 ±0.33	4.5 ±1.51	25 ±2.97
Shoot fresh wt(g.)	11.2 ±1.77	3.39 ±0.99	2.4 ±1.41	6.5 ±0.70	27 ±2.13	4 ±0.99	16 ±2.20	6.5 ±1.28	13.5 ±1.05	5.5 ±0.70	16 ±1.41	8.5 ±1.41	29 ±1.80	5.5 ±1.41	18 ±2.21	9 ±1.15	27 ±1.70	6.5 ±0.47	14.5 ±2.24	11.5 ±1.43
Root Dry wt.(g.)	3.45 ±0.78	1.15 ±0.34	1.2 ±1.53	6.5 ±1.41	10.25 ±1.41	1.25 ±0.34	3.0 ±1.41	7.5 ±1.32	6 ±2.08	1.5 ±0.34	3 ±0.35	9.5 ±0.70	11.24 ±2.26	2.5 ±0.34	4 ±1.41	9.5 ±1.17	9.24 ±2.09	3.5 ±0.98	3.19 ±1.58	13 ±1.42
Shoot Dry wt(g.)	6.48 ±1.71	1.49 ±1.01	5.2 ±1.41	3 ±0.70	19.2 ±2.37	2 ±0.99	9 ±1.77	3.5 ±0.71	7.5 ±1.18	3 ±0.97	9 ±1.41	5 ±0.94	20.24 ±2.41	2.40 ±0.98	7 ±0.35	5 ±1.70	14.42 ±2.63	4 ±0.99	5.89 ±1.49	6 ±1.41
Moisture %	46.89 ±1.93	58.02 ±2.85	52.2 ±1.84	53.46 ±1.84	39.2 ±2.69	50 ±3.26	47.8 ±2.08	59.25 ±2.2	40 ±2.70	47.05 ±3.29	42.8 ±1.57	46.2 ±1.98	36.04 ±2.71	45.5 ±3.55	56.86 ±2.6	47.2 ±1.99	48 ±2.48	37.50 ±1.41	52.21 ±2.61	47.9 ±2.01
R/S dry wt.Ratio	1.87 ±0.53	1.29 ±1.03	3 ±1.41	0.46 ±0.63	1.87 ±0.35	1.6 ±1.01	3 ±0.70	0.46 ±0.7	1.25 ±0.37	2.33 ±0.98	3 ±1.41	0.52 ±0.36	1.81 ±0.36	0.96 ±0.05	1.75 ±0.54	0.52 ±1.33	1.56 ±0.36	1.14 ±1.04	1.84 ±0.35	0.46 ±0.33

Table no. 15 (b) Effect of different IAA concentrations on (various growth parameters)of one year old seeding of *Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Control				25 ppm				50 ppm				75 ppm				100 ppm			
	Ds	Hi	Li	Ti	Ds	Hi	Li	Ti	Ds	Hi	Li	Ti	Ds	Hi	Li	Ti	Ds	Hi	Li	Ti
Root Length(cm)	30 ±0.70	34 ±0.70	85 ±1.77	33 ±1.41	44 ±2.03	50 ±1.30	100 ±2.20	50 ±1.70	32 ±1.94	40 ±0.70	90 ±1.70	48 ±1.80	40 ±1.74	47 ±2.47	55 ±1.63	47 ±1.92	33 ±1.93	38 ±1.74	72 ±1.63	40 ±1.41
Shoot Length(cm)	62 ±1.72	62 ±1.63	175 ±1.56	50 ±1.86	80 ±2.06	77 ±1.56	230 ±2.09	64 ±1.76	86 ±1.98	76 ±1.56	205 ±1.77	59 ±1.50	74 ±1.71	68 ±2.0	90 ±1.64	61 ±1.22	50 ±2.0	63 ±1.24	130 ±1.98	52 ±1.98
Plant Length(cm)	92 ±1.24	96 ±1.96	260 ±1.39	83 ±1.17	124 ±2.5	127 ±2.5	330 ±1.6	114 ±2.02	118 ±1.41	116 ±1.41	295 ±1.64	107 ±1.20	118 ±0.70	115 ±2.1	40.5 ±1.8	108 ±1.07	83 ±1.72	101 ±1.41	202 ±1.72	92 ±1.3
No.of Branches	25 ±1.63	22 ±1.41	42 ±1.18	25 ±1.63	30 ±2.06	21 ±1.65	52 ±0.70	35 ±1.59	35 ±1.49	34 ±0.70	47 ±0.35	36 ±1.63	20 ±0.70	26 ±1.85	36 ±1.41	32 ±0.57	22 ±1.36	24 ±1.84	30 ±1.77	27 ±1.7
Shoot/Root ratio	2.06 ±1.56	1.82 ±1.4	2.05 ±0.31	1.51 ±0.35	1.81 ±0.26	1.65 ±0.92	2.3 ±0.30	1.28 ±0.31	2.68 ±0.74	1.9 ±0.91	2.2 ±0.29	1.22 ±0.37	1.68 ±0.78	1.54 ±0.9	1.65 ±0.4	1.29 ±0.28	1.51 ±0.79	1.44 ±0.7	1.80 ±0.41	1.3 ±0.2
Root fresh wt.(g.)	9 ±1.77	3.5 ±1.68	45 ±1.35	4.5 ±0.96	15 ±1.24	8 ±1.20	63 ±1.17	4.25 ±0.97	11.5 ±1.44	8.5 ±1.35	43.5 ±0.71	3.5 ±1.04	12 ±1.73	9.5 ±1.47	45 ±1.05	4.8 ±0.35	5 ±1.57	5.5 ±1.36	44.5 ±0.85	7 ±0.81
shootfresh wt(g.)	14.5 ±1.25	8.5 ±1.42	190 ±1.58	13 ±1.03	20 ±1.70	19 ±0.96	2.55 ±1.22	12.4 ±1.02	29 ±2.35	35 ±1.5	244 ±0.67	8.5 ±0.78	16.5 ±1.25	21 ±1.65	155 ±1.28	18.5 ±0.75	7 ±1.71	15.5 ±0.35	65 ±1.91	18 ±0.70
Root Dry wt.(g.)	4.5 ±1.02	2 ±1.75	22.5 ±1.20	2.73 ±0.68	8.5 ±1.49	4.5 ±1.66	21.4 ±1.22	2.14 ±0.61	6.5 ±0.70	4.5 ±1.60	37 ±1.63	1.75 ±0.23	7 ±1.41	4.25 ±1.60	22.5 ±1.06	2.24 ±0.61	2.5 ±0.93	3 ±1.45	7.2 ±0.74	3.5 ±1.04
shootDry wt(g.)	7.5 ±1.78	4.5 ±1.43	84.8 ±1.42	5.5 ±0.98	13.5 ±1.8	11 ±1.42	129.4 ±1.2	6.25 ±0.93	15.4 ±1.23	19.5 ±1.6	135 ±1.56	4.24 ±1.00	8.5 ±1.77	11.2 ±1.41	74.2 ±1.62	10.4 ±0.95	3.5 ±0.93	8.5 ±0.70	27.2 ±1.23	9.4 ±0.33
Moisture %	48.93 ±2.51	45.8 ±2.4	54.3 ±1.56	53.62 ±1.2	37.14 ±0.77	42.5 ±2.56	49.39 ±1.62	49.2 ±1.33	45.9 ±2.46	44.8 ±2.48	44.05 ±1.56	50.08 ±1.93	45.6 ±2.59	49.3 ±2.55	516 ±1.42	45.04 ±1.4	50 ±2.70	45.23 ±2.47	56.72 ±1.49	48.4 ±0.9
R/S dry wt.Ratio	1.66 ±0.156	2.25 ±1.48	3.76 ±0.7	2.0 ±0.35	1.58 ±0.15	2.44 ±1.47	5.67 ±0.25	2.92 ±0.7	2.36 ±0.93	4.33 ±1.14	3.64 ±0.71	2.42 ±1.41	1.21 ±0.13	2.63 ±37	3.29 ±0.72	4.4 ±0.99	1.4 ±0.13	2.8 ±1.36	3.77 ±0.64	2.68 ±1.70

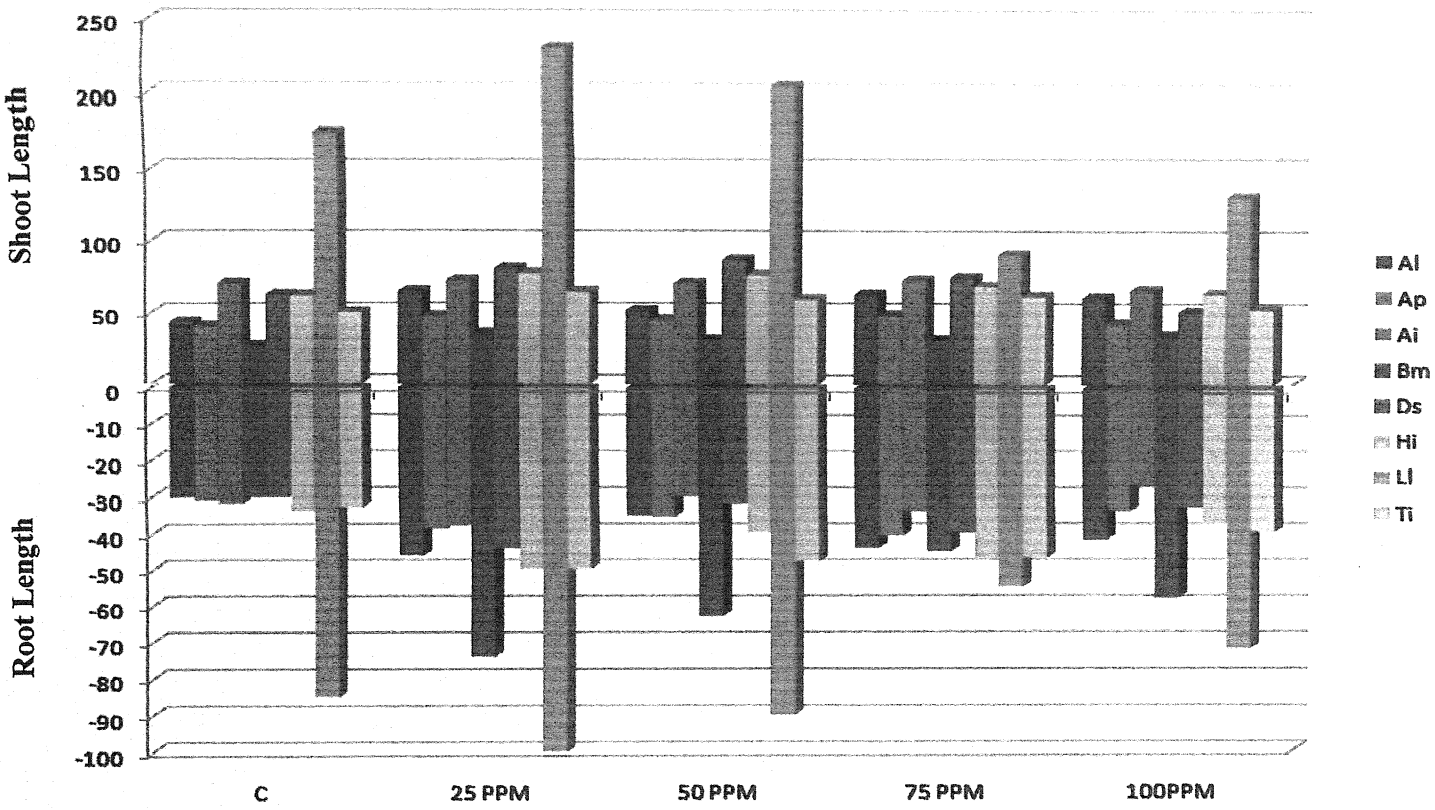


Fig. : 15 Effect of different IAA conditions on Root & Shoot length of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

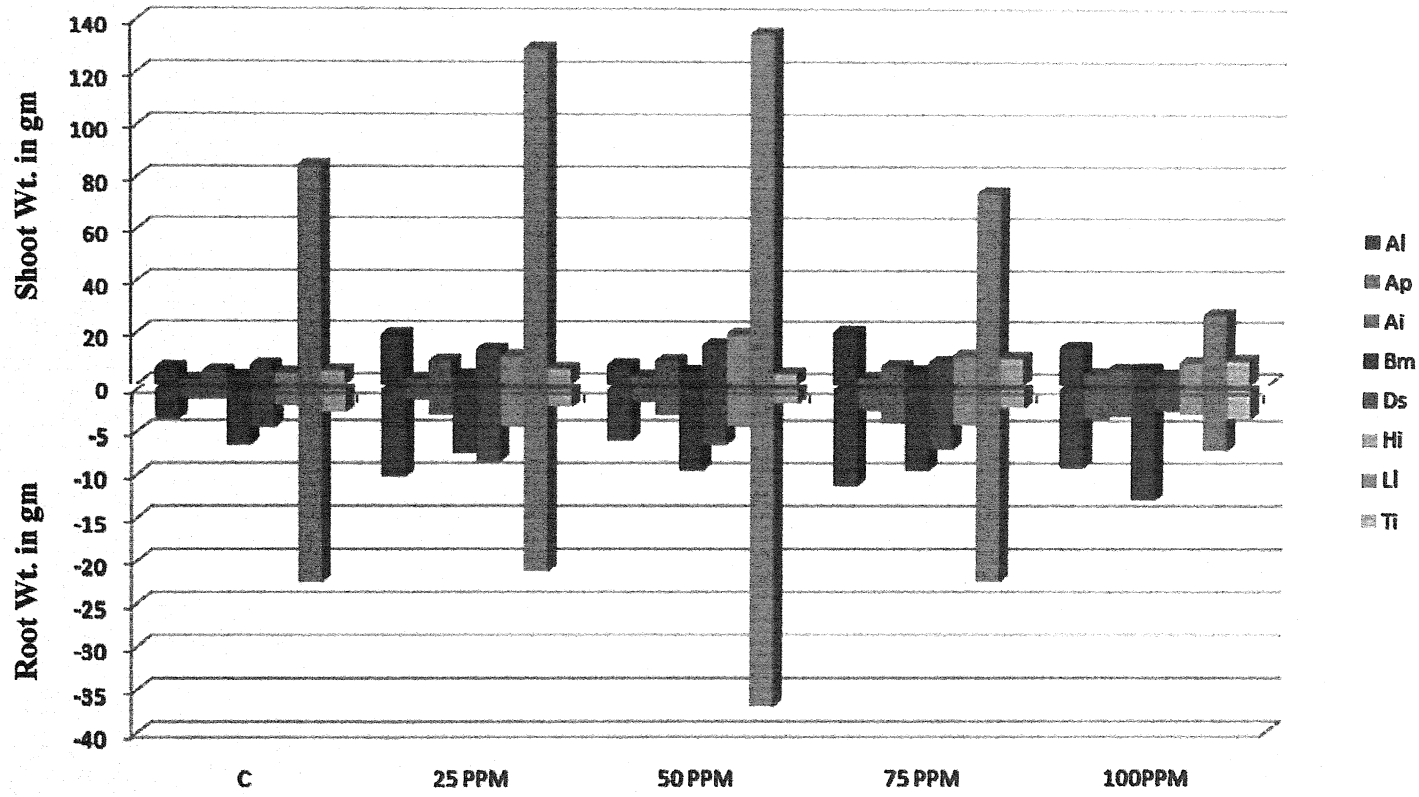


Fig. : 16 Effect of different IAA conditions on Root & Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus*

From the above observations, it was observed that maximum shoot length was observed in 25 ppm, but a gradual decrease was found with increase in concentration of IAA but its higher concentrations affect the shoot height adversely.

The highest dry weight of shoot was also observed in 25 ppm in all the species but the same concentration of IAA was not found effective with regards to root dry weight as it was showing a great variation with regards to concentration of IAA in different species.

The number of leaves was found maximum in 25 ppm concentration but there appears to be no definite trend of number of leaves in relation to different concentration of IAA. The occurrence of maximum number of leaves in 25 ppm might be due to better auxin activity at the apex of root and shoot.

Examination of data (Table 16 (A) and (B) and figure 17) on the effect of IBA treatment on seedling growth indicate that, on an average, the maximum root length in decreasing order was found as below but no relation of length of seedling could be established with a particular concentration of IBA as it greatly vary with species.

Leucaena leucocephala (155 cm) > *Butea monosperma* (74 cm) > *Albizzia lebbek* (70 cm) >

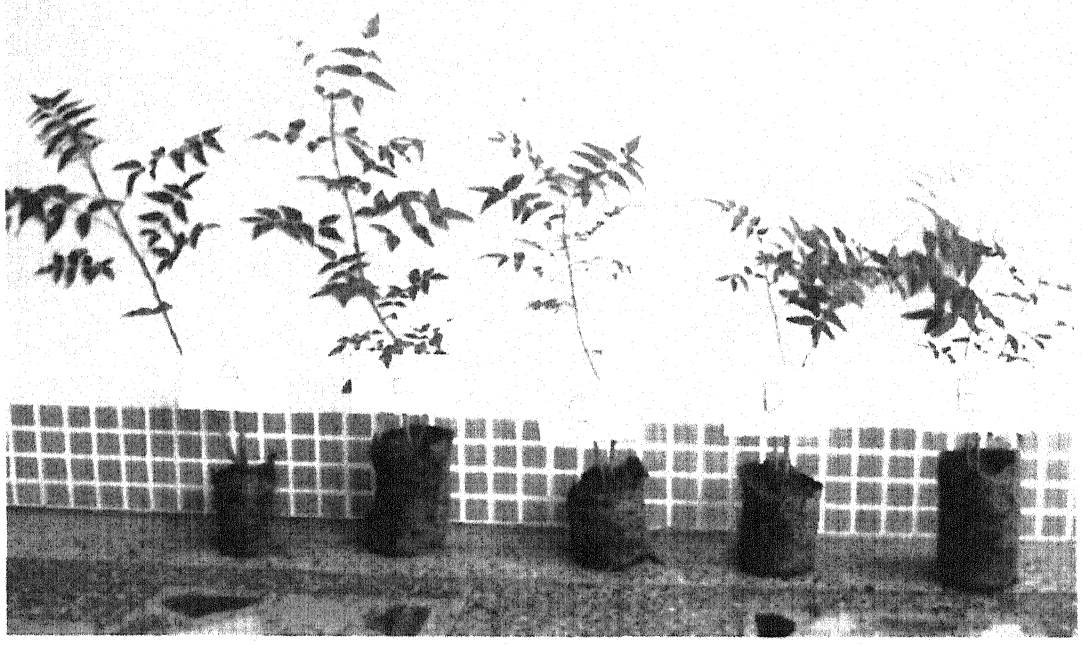
Tamarindus indica (50 cm) > *Albizzia procera* (42 cm) > *Holoptelia integrifolia* (39 cm) >

Dalbergia sissoo (42 cm) > *Azadirachta indica* (38 cm)

The observation on root length shows that root length was comparatively better in certain respects in 100 ppm of IBA treated plants but no response to IBA treatment was observed in *Azadirachta indica.* Again shoot growth was maximum in *Leucaena leucocephala* (300 cm) in 100 ppm concentration and a decreasing trend of growth was observed in *Albizzia lebbek* (100 cm), *Dalbergia sissoo* (76 cm), *Holoptelia integrifolia* (69 cm), *Tamarindus indica* (64 cm) and *Azadirachta indica* (155 cm). It appears that almost all the species thrives better in 100 ppm concentration of IBA treatment while

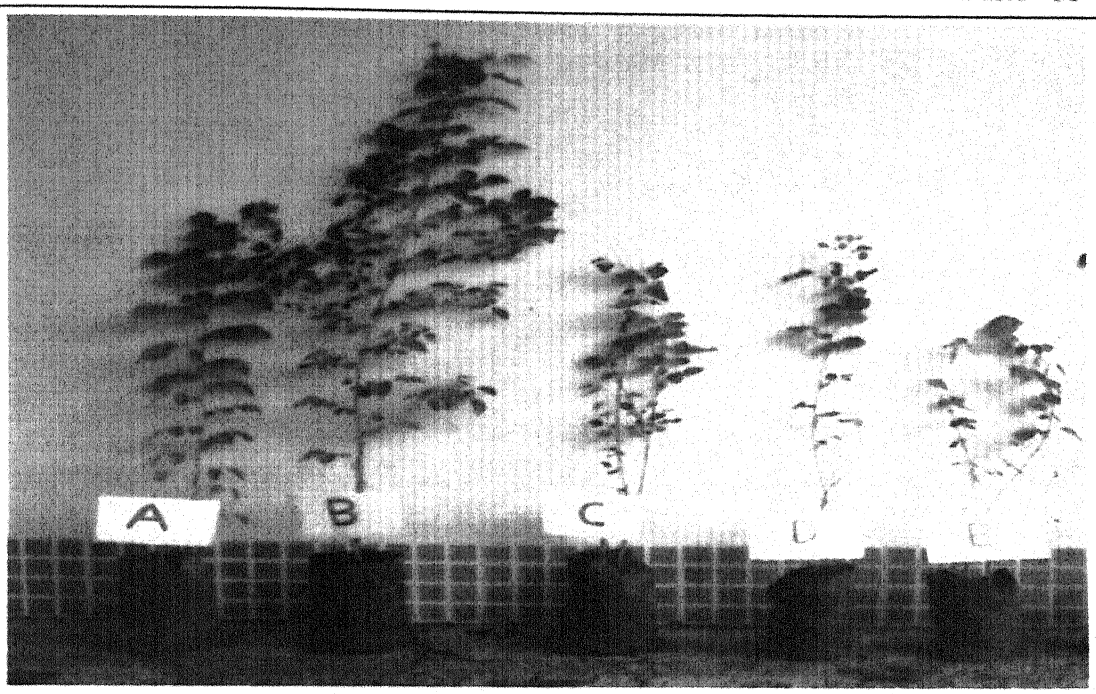
Effect of different IAA Concentrations on one year old seedling of *Albizzia lebbeck*

Effect of different IAA Concentrations on one year old seedling of *Albizzia procera*



Effect of different IAA Concentrations on one year old seedling of *Azadirachta indica*

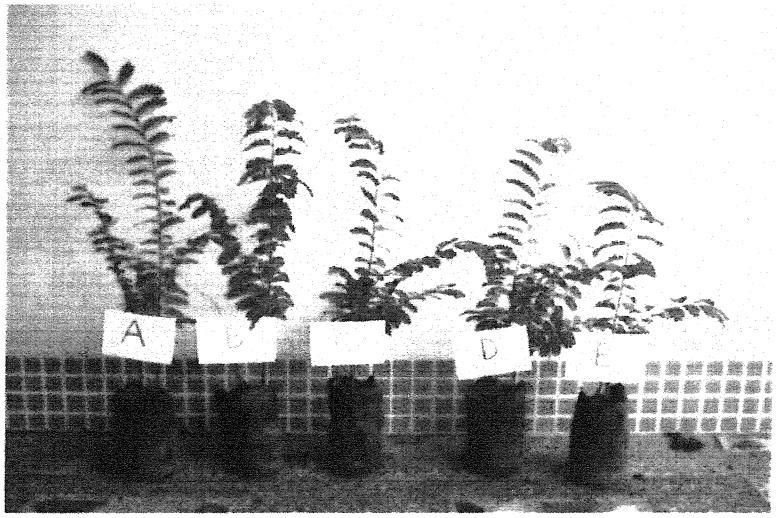
Effect of different IAA Concentrations on one year old seedling of *Butea monosperma*



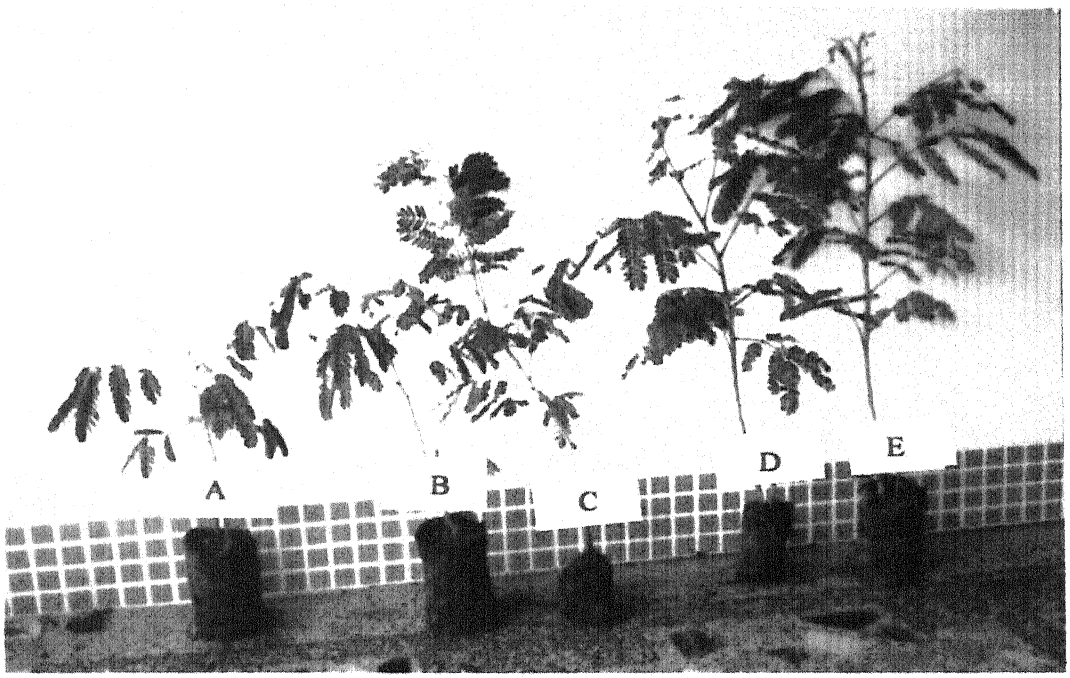
Effect of different IAA Concentrations on one year old seedling of *Dalbergia sissoo*

Effect of different IAA Concentrations on one year old seedling of *Holoptelia integrifolia*

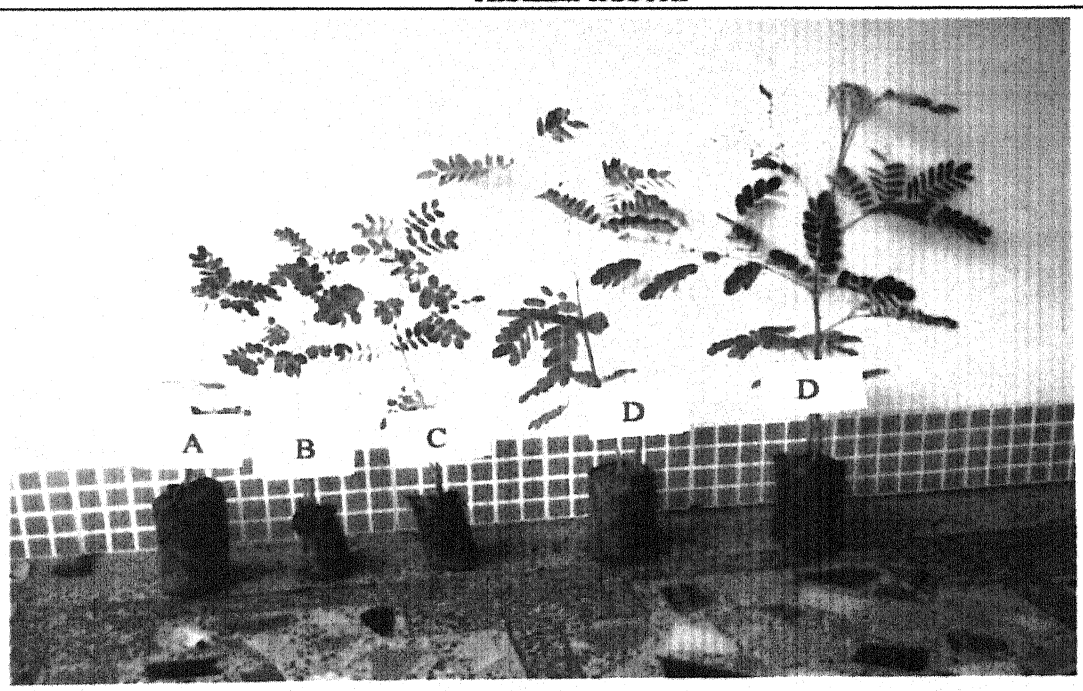
Effect of different IAA Concentrations on one year old seedling of *Leucaena leucocephala*



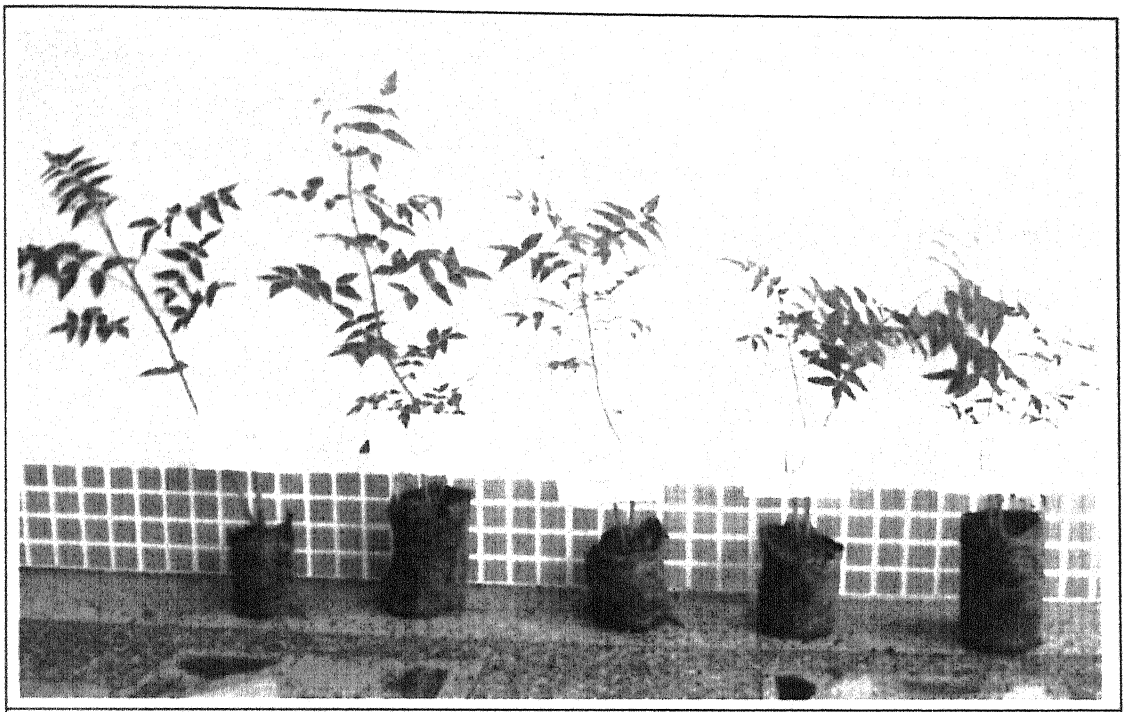
Effect of different IAA Concentrations on one year old seedling of *Tamarindus indica*



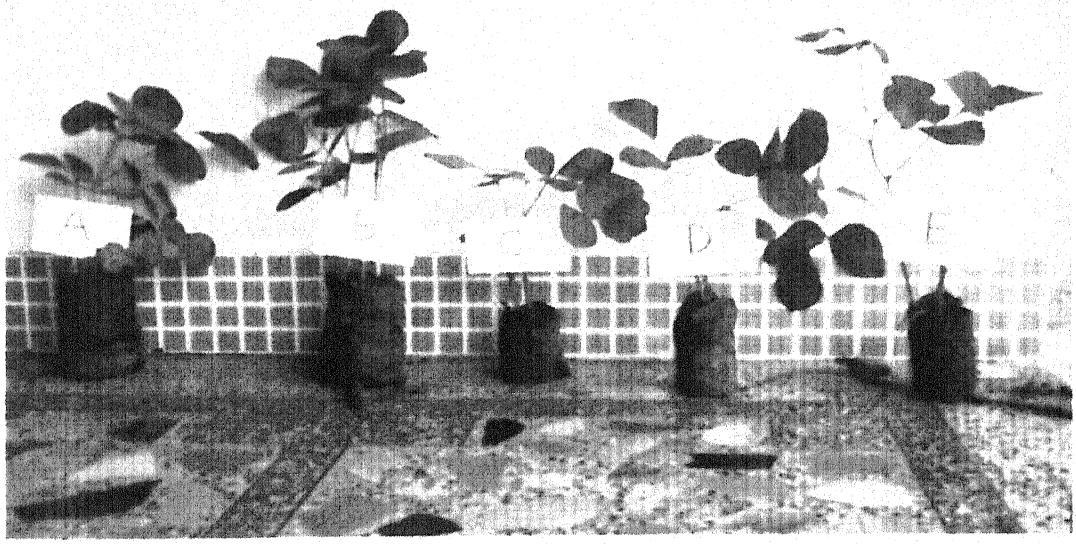
Effect of different IBA Concentrations on one year old seedling of Albizzia lebbeck



Effect of different IBA Concentrations on one year old seedling of *Albizzia procera*

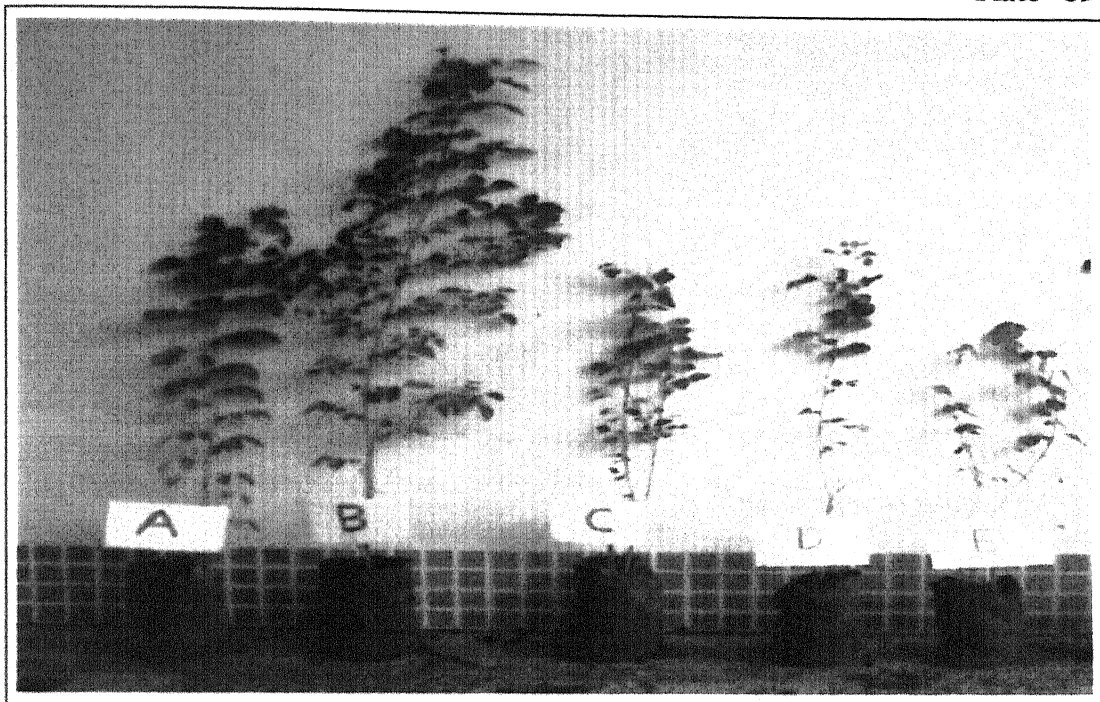


Effect of different IBA Concentrations on one year old seedling of Azadirachta indica

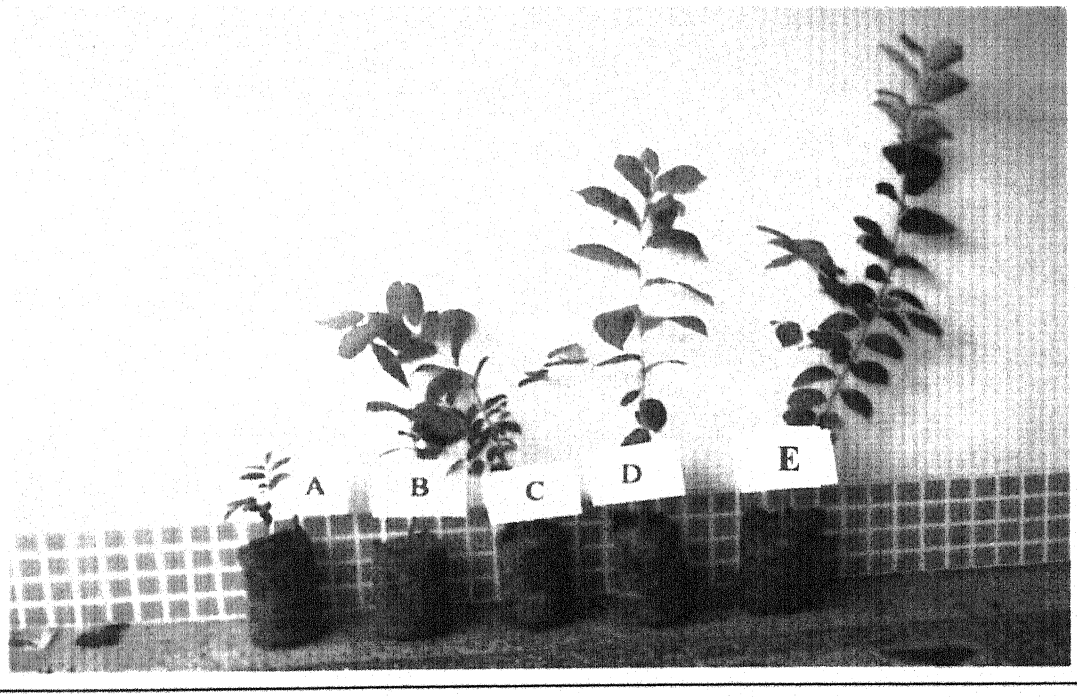


Effect of different IBA Concentrations on one year old seedling of *Butea monosperma*

Plate - 39

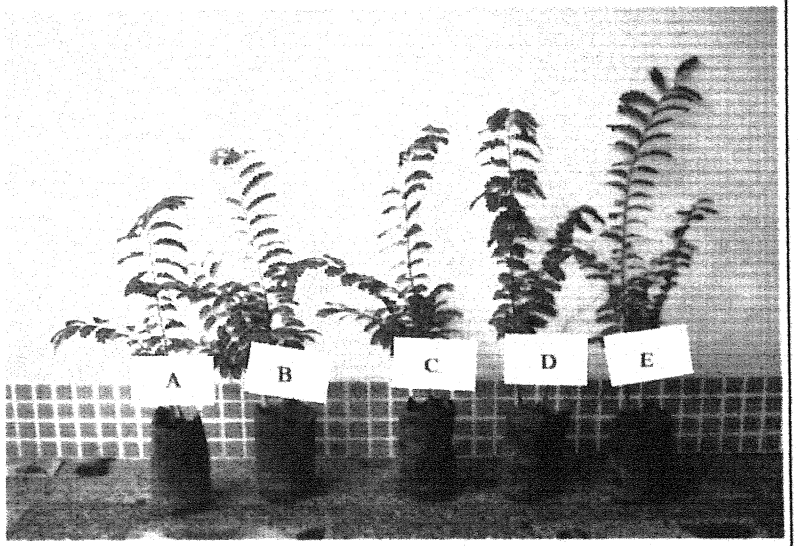


Effect of different IBA Concentrations on one year old seedling of Dalbergia sissoo



Effect of different IBA Concentrations on one year old seedling of *Holoptelia integrifolia*

Effect of different IBA Concentrations on one year old seedling of *Leucaena leucocephala*



Effect of different IBA Concentrations on one year old seedling of *Tamarindus indica*

minimum shoot growth was observed in *Albizzia procera* (52 cm) and *Butea monosperma* (41 cm) in 75 ppm concentration.

Number of branches was found maximum in *Leucaena leucocephala* (55 in 25 ppm). The ratio of shoot / root weight shows a different trend and it does not show clear cut pattern and it does not show any positive relation with treatment of IBA concentration. The shoot/ root ratio of seedlings also do not show any relation with IBA concentration.

On the basis of observations of overall results of IBA treatment, no conclusion could be made as the results were very much fluctuating and did not show any pattern but to some extent the response of seedling with 100 ppm concentration of IBA appear to be effective, and concentration below to it has a negative influence. On the basis of these experiments it can be concluded that, the range of different concentration of IBA used for treatment was ineffective to obtain better results, higher concentration should be tried.

Paul (1956) Stowe (1957), Chakravarti (1958), Nanda (1967), Abu zied (1973) reported that the GA treatment tend to increase the stem height and decrease the umbel number. Mehrotra and Dadwal (1978) have suggested that the application of GA at 100 ppm followed by weekly application of urea on *Tectona grandis* seedlings is more effective as it increases the overall growth of the plant.

In India, gibberllic acid has been successfully used to induce extensive growth in some forest species (Nanda and Purohit, 1964). Singh et al., (2000) have studied response of aged bamboo (*Dendrocalamus hamiltonii* L.) seeds to application of gibberlic acid and IBA. Gayatri et al. (2005) have tested seeds of some forest tree species for germination and seed borne fungi. Mohariya and Patil (2003) have studied response of different varieties of *Chrysanthemum* to growth regulators and observed different effect of different growth regulators. The effect of growth regulators on seed germination and growth performance of *Bridelia retusa* seed were studied by Chaturvedi and Bajpai (1999). More recently Massodi and Massodi (2000) described the growth behaviour and germination in *Ulmus wallichiana* seeds.

The treatment of GA of 1000 ppm on *Acacia* gave significant height growth, shoot and total dry weight in comparison to all other treatments (Bhatnagar and Singh, 1981). Mishra (1984) reported the application of lower dose of GA_3 10 ppm in *T. grandis* and 15 ppm in *D. strictus* induce a promotive effect on growth and dry weight of shoot and root respectively.

Table no. 16 (a) Effect of different IBA concentrations on (various growth parameters)of one year old seeding of *Albizzia lebbeck (Al) Albizia procera(Ap.)Azadirachta indica (Ai), Butea monosperma (Bm)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Control				25 ppm				50 ppm				75 ppm				100 ppm			
	Al	Ap	Ai	Bm	Al	Ap	Ai	Bm	Al	Ap	Ai	Bm	Al	Ap	Ai	Bm	Al	Ap	Ai	Bm
Root Length(cm)	49 ±0.92	35 ±1.52	38 ±1.98	58 ±1.98	56 ±1.49	40 ±1.71	28 ±1.86	47 ±1.77	60 ±1.63	42 ±1.74	27 ±1.80	48 ±0.47	45 ±1.84	40 ±1.41	29 ±1.53	50 ±1.24	70 ±2.42	41 ±1.72	31 ±0.39	74 ±1.49
Shoot Length(cm)	67 ± ±1.56	47 ±1.32	48 ±1.56	34 ±1.16	72 ±2.33	47 ±1.17	50 ±1.65	35 ±1.19	68 ±2.5	50 ±1.78	52 ±1.14	36 ±1.50	78 ±1.49	52 ±1.39	51 ±1.15	41 ±1.06	100 ±1.84	51 ±1.81	55 ±1.07	36 ±1.41
Plant Length(cm)	116 ±1.85	82 ±1.28	86 ±1.77	92 ±2.50	128 ±1.86	87 ±1.68	78 ±1.85	82 ±1.19	128 ±1.43	92 ±2.22	79 ±1.87	84 ±2.08	123 ±1.53	92 ±1.77	80 ±1.52	91 ±1.46	170 ±1.63	92 ±0.70	86 ±0.86	110 ±1.77
No.of Branches	10 ±1.49	14 ±1.06	29 ±1.32	4 ±0.86	15 ±0.70	15 ±1.05	32 ±1.96	4 ±0.70	12 ±1.53	12 ±1.10	22 ±0.92	5 ±0.35	13 ±1.63	10 ±1.15	24 ±1.15	5 ±1.41	15 ±1.41	12 ±0.96	21 ±1.24	9 ±1.15
Shoot/Root ratio	1.14 ±0.55	1.35 ±0.75	1.26 ±0.28	0.58 ±0.52	1.63 ±0.53	1.17 ±0.76	1.78 ±0.3	0.74 ±0.5	1.13 ±0.39	1.19 ±0.59	1.77 ±0.32	0.75 ±0.50	1.73 ±0.38	1.3 ±0.50	1.75 ±0.3	0.82 ±0.49	1.42 ±0.34	1.24 ±0.50	1.92 ±0.33	0.48 ±0.5
Root fresh wt.(g.)	12.5 ±1.18	5.5 ±0.29	6.5 ±1.48	18.5 ±1	31 ±1.63	5.5 ±0.70	7.5 ±1.44	25 ±1.39	27.9 ±1.86	6.5 ±0.51	6.8 ±1.47	21.5 ±0.99	21.5 ±0.73	5.5 ±0.29	5.5 ±0.75	35.8 ±1.50	46.5 ±1.41	5.4 ±0.29	15.5 ±1.03	18.9 ±1.008
shootfresh wt(g.)	12.5 ±1.13	6.5 ±0.45	12.5 ±0.81	9 ±1.15	45.5 ±1.83	6.2 ±0.46	12 ±0.85	11.5 ±1.06	42.4 ±1.91	4.0 ±0.42	12 ±0.70	10.5 ±1.07	52 ±1.35	6.5 ±0.45	3.5 ±0.54	13.5 ±1.21	52.5 ±1.22	3.7 ±0.43	11 ±1.46	12.5 ±1.09
Root Dry wt.(g.)	5.82 ±0.72	3.5 ±0.38	6.9 ±1.46	9.5 ±0.40	13.5 ±1.20	3.5 ±0.35	7.2 ±1.45	13 ±1.16	15.8 ±0.91	2.21 ±0.48	7.8 ±1.43	10 ±0.46	13.5 ±1.08	3.42 ±0.60	1.90 ±0.64	9.45 ±0.40	27.5 ±1.53	2.02 ±0.48	5.5 ±0.64	16.98 ±1.35
shootDry wt(g.)	6.41 ±0.77	4.0 ±0.42	9.5 ±1.44	5 ±0.50	21 ±0.78	3.8 ±0.38	9.7 ±1.45	6 ±0.53	24.89 ±1.31	3.82 ±0.5	9.4 ±1.41	5.5 ±0.46	33.5 ±1.40	3.98 ±0.54	4.24 ±0.81	6.25 ±0.52	31.4 ±0.80	3.09 ±0.61	13.24 ±0.75	6.7 ±0.5
Moisture %	51.2 ±1.98	37.5 ±1.07	13.48 ±0.81	47.2 ±1.7	54.9 ±1.06	37.4 ±1.07	13.07 ±0.81	47.9 ±1.73	42.09 ±0.64	42.5 ±1.7	8.5 ±0.70	51.5 ±1.77	36.1 ±1.00	38.3 ±0.71	78.89 ±1.41	50 ±1.72	40.5 ±1.98	43.9 ±0.11	29.2 ±1.41	51.8 ±1.7
R/S dry wt.Ratio	1.10 ±0.35	1.14 ±0.50	1.36 ±0.69	0.5 ±0.51	1.55 ±0.34	1.09 ±0.51	1.35 ±0.51	0.4 ±0.35	1.57 ±0.35	1.72 ±0.45	1.20 ±0.71	0.55 ±0.35	2.47 ±0.49	1.16 ±0.50	2.23 ±0.45	0.66 ±0.31	1.14 ±0.36	1.52 ±0.49	2.40 ±0.35	0.39 ±0.3

Table no. 16(b) Effect of different IBA concentrations on (various growth parameters)of one year old seeding of *Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti)* (average value of 5 Replicates). Values are Mean ± S.E.

Various measurement of seedlings	Control				25 ppm				50 ppm				75 ppm				100 ppm			
	Ds	Hi	Ll	Ti	Ds	Hi	Ll	Ti	Ds	Hi	Ll	Ti	Ds	Hi	Ll	Ti	Ds	Hi	Ll	Ti
Root Length(cm)	35 ±1.18	32 ±1.20	90 ±2.22	35 ±1.52	32 ±1.20	34.7 ±1.52	108 ±1.86	43 ±0.10	30 ±1.30	38.8 ±1.98	110 ±1.92	42 ±1.74	34 ±0.89	39.2 ±1.68	140 ±1.56	35 ±1.41	42 ±1.10	39.4 ±1.71	155 ±1.84	49 ±0.92
Shoot Length(cm)	62 ±2.33	60 ±1.63	200 ±1.59	72 ±2.33	58 ±2.70	64 ±1.41	180 ±1.63	74 ±1.34	65 ±2.58	67 ±1.56	225 ±1.38	76 ±2.21	70 ±1.42	68 ±2.30	196 ±1.24	77 ±1.06	76 ±2.21	69 ±1.41	300 ±1.56	74 ±1.49
Plant Length(cm)	97 ±1.41	92 ±1.1	290 ±2.22	107 ±1.70	100 ±1.30	98.7 ±2.63	288 ±2.20	117 ±1.004	95 ±1.53	1.5.8 ±1.5	335 ±1.67	118 ±1.24	1.40 ±0.70	107 ±1.70	336 ±1.50	122 ±2.002	118 ±1.24	10.84 ±1.94	455 ±1.41	133 ±1.05
No.of Branches	40 ±1.56	27 ±1.80	42 ±1.74	50 ±1.65	18 ±1.28	28 ±1.42	55 ±0.96	54 ±1.49	44 ±1.07	26 ±1.42	51 ±1.58	40 ±1.71	28 ±1.51	27 ±1.77	45 ±2.29	55 ±1.01	28 ±1.47	28 ±1.42	40 ±0.70	40 ±1.41
Shoot/Root ratio	1.77 ±124	1.87 ±0.6	2.22 ±0.38	1.67 ±0.45	1.81 ±0.81	1.84 ±0.57	1.93 ±0.31	2.11 ±0.48	2.16 ±0.19	1.72 ±0.54	2.40 ±0.3	1.73 ±0.45	1.80 ±0.23	1.73 ±0.54	1.4 ±0.34	2.2 ±0.48	2.05 ±02	1.75 ±0.55	1.66 ±0.39	1.51 ±0.19
Root fresh wt.(g.)	4.5 ±0.94	3.5 ±0.28	57 ±0.58	3 ±1.06	5.5 ±0.56	9±1.17	219 ±0.01	7.5 ±1.44	9.5 ±0.70	8 ±1.16	65.5 ±0.70	4.5 ±0.57	10.5 ±011	5.5 ±0.72	245 ±1.14	7.5 ±1.44	5.5 ±0.35	9.5 ±1.18	219±0.0 1	5.5 ±0.72
Shoot fresh wt(g.)	10 ±0.70	8.8 ±1.17	198.5 ±0.75	13 ±1.02	8 ±0.96	12 ±1.02	210 ±0.70	27.5 ±1.47	16 ±2.39	19 ±1.24	188 ±1.49	16.5 ±2.39	16 ±1.46	15.5 ±1.85	142 ±1.41	21.5 ±0.99	13.2 ±1.44	21 ±1.39	720 ±0.70	20.5 ±1.39
Root Dry wt.(g.)	2 ±0.67	2 ±0.55	26 ±0.98	1.5 ±0.81	2.75 ±0.70	3 ±1.06	126.7 ±1.07	3.24 ±0.70	4.5 ±0.86	4 ±1.05	32.7 ±0.9	2.75 ±0.40	5.5 ±0.56	2.75 ±0.56	126 ±0.28	3.74 ±0.55	2.75 ±0.75	4.7 ±1.07	105.4±1. 67	2.75 ±0.52
Shoot Dry wt(g.)	4.5 ±0.50	4.5 ±0.57	83 ±0.88	6.78 ±0.61	4 ±0.42	5.5 ±0.70	11.4 ±1.41	12.5 ±0.81	9.5 ±0.92	9.5 ±1.06	97.4 ±1.18	8.74 ±1.19	8 ±0.70	7.74 ±1.03	72 ±1.41	10.48 ±1.07	6.8 ±0.72	10.48 ±1.02	204.8 ±1.41	10.2 ±0.93
Moisture %	55.1 ±2.01	47.1 ±1.73	57.3 ±1.06	48.2 ±1.75	50 ±1.30	60.4 ±0.35	66.9 ±107	55.0 ±2.01	45.09 ±0.89	50 ±1.53	48.6 ±0.94	45.28 ±1.16	49 ±0.89	50.04 ±1.41	71.5 ±1.03	50.96 ±1.30	48.7 ±0.94	50 ±1.41	66.9 ±1.07	50.03 ±1.4
R/S dry wt.Ratio	2.25 ±0.67	2.25 ±1.03	3.19 ±0.44	4.5 ±0.86	1.45 ±0.35	1.83 ±0.30	1.93 ±0.30	3.85 ±0.70	2.11 ±0.66	37 ±0.71	2.9 ±0.37	3.17 ±0.44	1.45 ±0.70	2.81 ±0.70	2.66 ±0.36	2.8 ±0.52	2.48 ±0.30	2.21 ±0.72	1.93 ±0.30	3.72 ±0.42

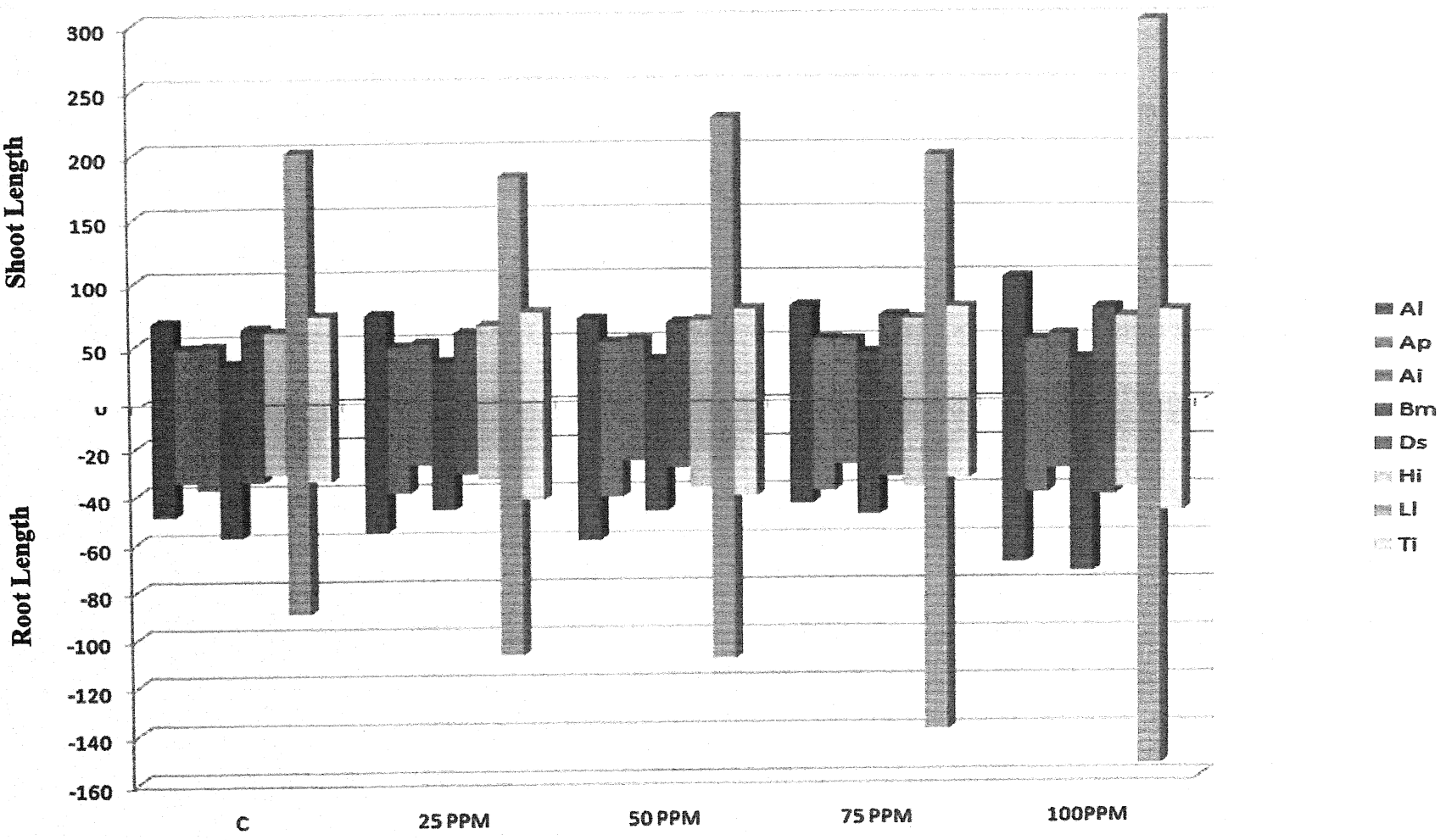


Fig. : 17 Effect of different IBA conditions on Root & Shoot length of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

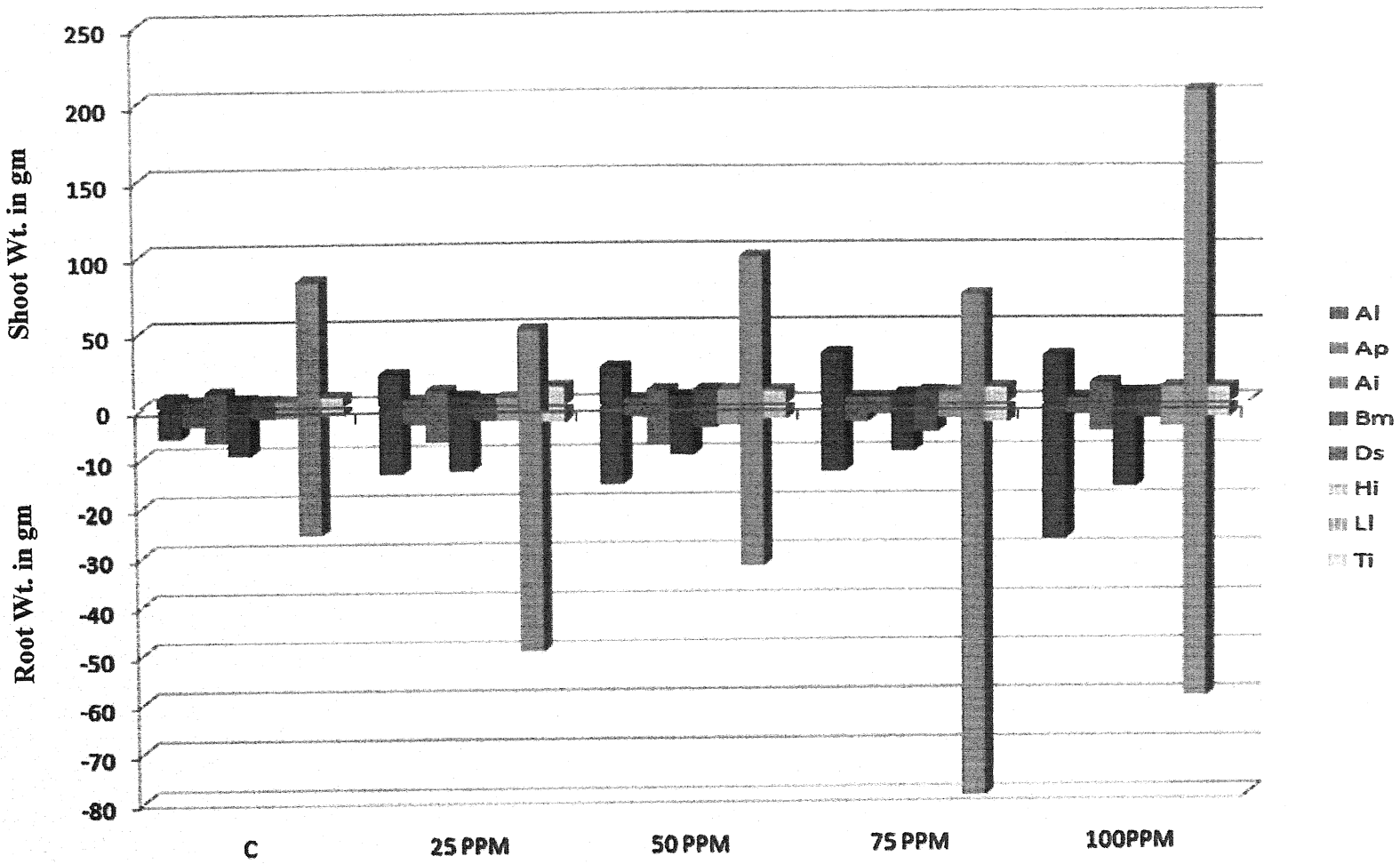


Fig. : 18 Effect of different IBA conditions on Root & Shoot Dry Wt. of one year old seeding of *Albizzia lebbeck (Al), Albizia procera(Ap.)Azadirachta indica (Ai) Butea monosperma (Bm), Dalbergia sissoo (Ds), Holopetelia integrifolia (Hi), Leucaena leucocephala (Ll) and Tamarindus indica (Ti).*

The application of difference doses of GA_3 increased shoot growth of seedling but its effect on root growth was retarding. Talwar and Bhatnagar (1978) during their study on *Pinus caribaea* seedlings found that the 10 ppm concentration of IAA has given maximum fresh and dry weight. Sircar (1965) has observed that application of GA brought about stem extension and number of internodes but decrease leaf expansion, basal thickness of stem, lateral bud development and fiber growth particularly at relative higher concentration. Applications of IAA on the other hand result in increased growth of the plant in most respects.

Hormones play an important role in seed germination. Germination studies of some economically useful species need priority attention to include them in plantation programmes. Seed dormancy is a major constraint faced by nursery operators as they have to obtain healthy and uniform seedlings for crop. The problems are more severe for hard seed coat species. Thus enhancing germination by treating seeds with acids or scarification of seed coat to break dormancy is of physiological and practical importance (Kramer and Kozlowski, 1979). The effect of growth regulators on seed germination of 20 species of forest plants was studied by Baines (1980). Singh and Nayar (2002) described the application of Gibberllic acid and *I*ndole 3 butyric acid to seed of aged bamboo (*Dendrocalamus hamilttoni* L. Hungro). *Ficus auriculate* and *F. glomerata* also reported higher stem cutting, sprouting when treated with IAA and IBA.

SUMMARY AND CONCLUSION

The present study was planned to understand the behaviour of seeds and the seedlings of some important forest tree species. The object of this study was to have some idea about seed germination and establishment of seedling which may be useful for afforestation and reforestation practices in Bundelkhand region. The study was carried out on some common dry deciduous forest tree seeds/fruits. Selected species are *Albizzia lebbek, Albizzia procera, Azadirachta indica, Butea monosperma, Dalbergia sissoo, Holoptelia integrifolia, Leucaena leucocephala and Tamarindus indica.*

Seed collection from fruit was done during the year 2004, from the month of April to July and was carried out from forest of Bangawa, Chandpura and Laxman Pura which are situated in Jhansi range of U.P. and Tikamgarh range of M.P. The experiments were performed in Bangwan, state Government nursery, 15 Km. from Jhansi on Jhansi-Mauranipur Road

Seed/Fruits germination behaviour was studied in relation to controlled (Seed germinator) and semi controlled environment (nursery bed), dimensions, seed viability, pretreatments (to break seed dormancy), seed storage, duration of imbibitions and temperature.

Seedling growth performance in relation to different light conditions, irrigation regimes, potting media and different concentrations of hormones was studied. Analysis of growth performance of seedling has been made in terms of length of root and shoot, number of leaves and branches per seedling, fresh and dry weight of root and shoot, root/shoot dry weight ratio of these seedlings in response to various factors have also been estimated.

Seeds in general, decrease their viability if collection time is delayed and the seeds with heavy weight and larger dimension are associated with increased viability and better percentage germination probably due to large amount of food capital stored in them. Among these, the seeds of *Butea monosperma* were found to have maximum weight (1.11 gm) and size (4.5 cm). The seeds of *Holoptelia integrifolia* (3 cm in length) were found small in respect to all parameters as compared to other species. The pods of *Albizzia lebbeck* (9.61 cm) were found to possess maximum length.

In most of species, the emergence time ranged between 4 and 9 days. Similarly, the time required for completion of germination varied from 6 to 13 days in almost all the selected forest species. The seeds of *Azadirachta indica* and *Butea monosperma* required minimum time for emergence i.e. 4 and 5 days respectively. On an average, maximum germination (66%) was found in *Butea monsperma* and minimum was recorded in *Holoptelia integrifolia* (24%). The percentage germination of seeds in nursery was comparatively less than in the germinator.

Often a pretreatment is used to hasten germination, or to obtain a more even germination the treatment varies with the different type of dormancy of tree seeds. Results indicate that seed germination and seedling growth in *Albizzia procera* was found to be better in seeds soaked in water at room temperature (30° C) for 24 hours. Similarly the seed germination and seedling growth of *A. lebbek* was more pronounced in water as compared to unsoaked seeds. It is well known that *Azadirachta indica* seeds have a short span of viability the seeds were stored for different period under different conditions and containers. Seeds of *Dalbergia sissoo* show higher germination when soaked in water at 30°C for 24 hours than that of unsoaked seeds while the seeds of *Butea monosperma* exhibits the higher percentage of germination at presoaking in water only to a period of 6 hours. Seeds of *Leucaena leucocephala* show maximum percentage of germination if pretreated with concentrated H_2SO_4 for a period of 3 minutes. Seeds of *Holoptelia integrifolia* do not need scarification and direct sowing is more effective in this species.

Storage of seeds before germination affects the germination percentage of seeds. A careful perusal of the results of selected species reveal that the germinability of seeds of all these species exhibit a trend of sharp decline in germination percentage at room temperature with increase in storage period from fresh seeds to twelve month old seeds. The decrease in percentage germination after one year storage was found 36.84% in *Leucaena leucocephala*, 48.38% in *Dalbergia sissoo*, 83.33% in *Holoptelia integrifolia*, 35% in *Tamarindus indica*, 58.82% in *Azadirachta indica*, 52.43% in *Butea monosperma*, 60% in *Albizzia procera*, and 57.69% in *Albizzia lebbek*.

Positive relationship was found in between duration of imbibitions and germination of all the species except for *Butea monosperma* where percentage germination increased up to 6 hours of presoaking and then declined. During 48 hours of

presoaking, maximum germination (72%) was found in *Leucaena leucocephala* and minimum (10.67) in *Tamarindus indica*. Heavy weighted seeds were found to have better germination then the light weighted seeds in almost all the species studied.

The optimum temperature for germination of the seeds of these species was found to be 30^0 C. No seeds could germinate below 20^0 C and above 35^0 C temperatures. These differences in germination behavior of seeds at different temperature may be due to the sensitivity of various physiological processes of germination and at 30^0C temperature; these processes operate at optimum rate.

The effect of light condition on seedling growth was considerably significant. Seedlings were grown in three conditions i.e. full sunlight, semi shade and diffused light, plants were exposed for one year. Optimum growth was found in open sunlight (100%) than semi shade (45%) and shade (20%). The maximum length of root (177.5 cm) and shoot (222 cm) was obtained in 100% of light in case of *Leucaena leucocephala* while minimum growth was observed in *Holoptelia integrifolia* in 20% of light condition.

Dry weight was found maximum in *Leucaena leucocephala* in 100% light than 45 and 20% of light conditions. Minimum root weight was observed in *Holoptelia integrifolia* in diffused light. The percentage moisture content was found greater in 45% light followed by 100% and 20% light respectively within seedling of all the species.

The root/shoot ratio shows an increasing trend gradually in 45 < 100<20 percent light condition. The average number of branches was observed higher (59.5) in case of *Leucaena leucocephala* and lowest (1.5) in *Dalbergia sissoo* in 20 percent light. Although a very significant difference in not seen in semi shady and full sunlight condition but a sharp decline is observed in diffused light condition.

An examination of data reveals that maximum root and shoot length was found in irrigation category II and decreasing order was followed by category I and III. The length of shoot was almost equal in category I and II category. Thus a total length of plant shows an increasing trend from category II>I >III. Percent moisture content in root was higher in I and II category as compared to III one. In shoot, percentage of moisture content followed the trend of decrease from I >III >II category of irrigation. The dry weight of root and shoot was higher in *Leucaena leucocephala* (89.2 gm and 309 gm) in

case of I category of irrigation. The higher number of leaves were observed in I category of irrigation which declines gradually from II to III category.

Therefore on the basis of above observations it can be concluded that on average, the growth of seedlings was found better in alternate irrigation. (II category). The better growth performance of seedlings in alternate irrigation would have resulted due to setting better environment of soil (i.e. moderate moisture content and proper aeration condition) to the seedling of these species. The seedlings of daily irrigation might have suffered with low aeration and excessive wet soil condition which might have slowed down the growth of seedlings. Similarly the twice/weekly irrigated seedlings except *Leucaena* would have suffered with low moisture availability which might have checked the proper growth of seedlings in this case.

The data of seedlings growth in relation to different potting media revealed that maximum dry weight of seedlings (665gm.) was found in medium S_7 in case of *Leucaena leucocephala.* Dry weight of shoot and root in all the cases was found maximum in the medium S_7 followed a decreasing trend with medium $S_5 > S_2 > S_6$ respectively. This may be due to setting better aeration and appropriate soil moisture and nutrition, which favours the growth of seedlings of species. There is no relation between the numbers of leaves/seedling with potting media used. No trend of any relaton of root/shoot dry weight ratio with potting media could be detected as there were many variations in the data of seedlings of almost all the species as regards to different potting media tried for their growth. The medium S_7 is supposed to be an appropriate medium for obtaining good length of shoot in most of the species except *Albizzia procera* and *Dalbergia sissoo* which showed good performance of their shoot length in the media S_1 and S_2, respectively

The effect of different concentration of IAA on seed germination indicates that maximum shoot length was observed in 25 ppm, but a gradual decrease was found with increase in concentration of IAA as its higher concentrations affect the shoot height adversely

On the basis of observations of overall results of IBA treatment, no conclusion could be made as the results were very much flunctuating and did not show any pattern, but to some extent the response of seedling with 100 ppm concentration of IBA appear to be effective, and concentration below to it has a negative influence. On the basis of these

experiments it can be concluded that, the range of different concentration of IBA used for treatment was ineffective to obtain better results, higher concentration should be tried.

It is apparent that little work has been done on tropical forest tree seeds and their germination, and seedling growth as compared to agricultural and horticultural seeds. As it is a well known fact that environment and plants are closely interrelated and have a greater bearing on seed and its germination growth and development of plant etc. It becomes inevitable to understand the ecological factors which are wholly responsible for growth and further development of plant. It is an essential basis for the formation value of seed. It is a common view now to protect the environment; one has to depend for more and more afforestation and reforestation programmes. The understanding of better quality of seeds and their better germination is the prerequisite of these programmers. Keeping this view in mind the present study was planned to have a scientific understanding of seed ecology of tropical forest tree species.

To achieve success in any plantation program, a good start is essential from the generation stage in order that seed can germinate; it must be placed in environmental conditions favourable to this process. These include adequate moisture supply, appropriate moisture balance and light for certain seeds. In several important species germination processes can be enhanced to levels by appropriate seed pretreatments

On the whole it can be concluded that collection of healthy seeds/ fruits which have good amount of stored food, treatment of seeds/fruits with various physical and chemical devices, suitable potting media and early seedlings growth and their aftercare seems to be most important aspects, hence these practices should be implemented in nursery raised seedlings. Following are some suggestions to improve germination and seedling growth especially for dry deciduous forest species.

1. To improve plantation quality, the use of good quality seeds must be ensured and procurement sources for the continuous production of commercial quantities of improved seeds must be established.
2. Collection of seeds should be made from middle aged healthy parent tree occurring in different localities in order to include seed types for better germination and quality
3. Large/medium sized seed (on the basis of weight) could be considered separately to get better germination and equal size planting stumps.

4. Pre-soaking of seeds/fruits before sowing for different duration in water could be taken into consideration to facilitate quick and better germination in nursery bed. Comparatively longer duration of pre-soaking in water in case of hard coated seeds (*Leucaena leucocephala*) is more desirable while reverse is true for soft seeded seeds (*Butea monosperma*, *Dalbergia sissoo*).
5. Potting media also seemed to play important role during the course of seedling development and it is desirable that suitable medium should be used, while preparing the planting stumps, as survival and establishment of the planting stumps depends on its quality. The medium S_7 (Mixed) is supposed to be an appropriate medium for obtaining good length of shoot in most of the species except *Albizzia procera* and *Dalbergia sissoo* which showed good performance of their shoot length in the media S_1 (Red) and S_2 (Black) respectively. This may be due to better aeration and appropriate water retaining capacity of the medium S_7, which is favourable for the growth of these species. Contrary to this minimum growth in medium (S_4) may be due to lesser aeration and more water retaining capacity than earlier ones.
6. Proper attention must be paid in nursery during the late winter/summer, because during that duration environmental stresses are more acute, which affect the pace of growth considerably in the early and late stages of growth of seedling.

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